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EVALUATION OF JTWC TROPICAL CYCLONE OBJECTIVE FORECAST AIDS (1978-85)

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The Joint Typhoon Warning Center (JTWC) official and objective aid forecasts for the Western North Pacific tropical cyclones during 1978-85 are evaluated. Forecast accuracy and consistency are judged on such error measures as forecast error, cross-track error, along-track error, track error, speed error and timing error, with respect to the best track of the tropical cyclone. Data also are stratified by the storm's intensity, type of path, and season, for futher detailed comparisons. Considering all data groups, HPAC and OTCM emerged as the best and most consistent aids for the entire data period. Other aids, however, can surpass these two aids in specific synoptic situations. When tropical cyclones are in tropical storm stage, JTWC forecasts are most reliable. Two new aids introduced to JTWC in 1985 were among the best aids of that year. (KR)

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1. INTRODUCTION

When a tropical cyclone or a tropical depression threatens the western North Pacific region, the Joint Typhoon Warning Center (JTWC) in Guam is responsible for providing tropical cyclone forecasts and warnings to all U.S. concerns.

At present, up to 26 objective tropical cyclone track forecast aids are available to JTWC forecasters. Although these aids appear to give substantial assistance, they usually conflict with one another (Figure 1) and seldom provide uniform and coherent guidance. Using the current synoptic pattern, it is the duty forecaster's responsibility to select the proper objective aid. In deliberation, forecasters may opt for aids they are familiar with and forgo other aid(s) that may be more suitable for the situation. As a result of this familiarity, forecasters may face a long learning period before accepting these other "aids." To shorten the learning process, periodic reviews must be made to reveal the performance characteristics of these objective aids. The goals of this study are to examine systematically the operational performance characteristics of all JTWC objective forecast aids, and to explore the means to use these characteristic statistics for forecast adjustments.

Past studies on Atlantic hurricanes (Neumann and Pelissier, 1981; Neumann, 1981a,b) suggested that, despite the advances of computer technology, the improvement in the quality of satellite images and the introduction of sophisticated objective techniques, including numerical tropical cyclone models, have improved official forecast skills only slightly since 1970. As shown by Jarrell et al. (1978) and Figure 2, a similar predicament applies to the JTWC's skill in forecasting the western North Pacific tropical cyclones. To rectify the situation, many new aids for improving forecast guidance were introduced. This introduction of new aids, however, may not be the most efficient way to improve forecasts; it may even be counterproductive because more aids simply cause greater confusion (Neumann and Pelissier,

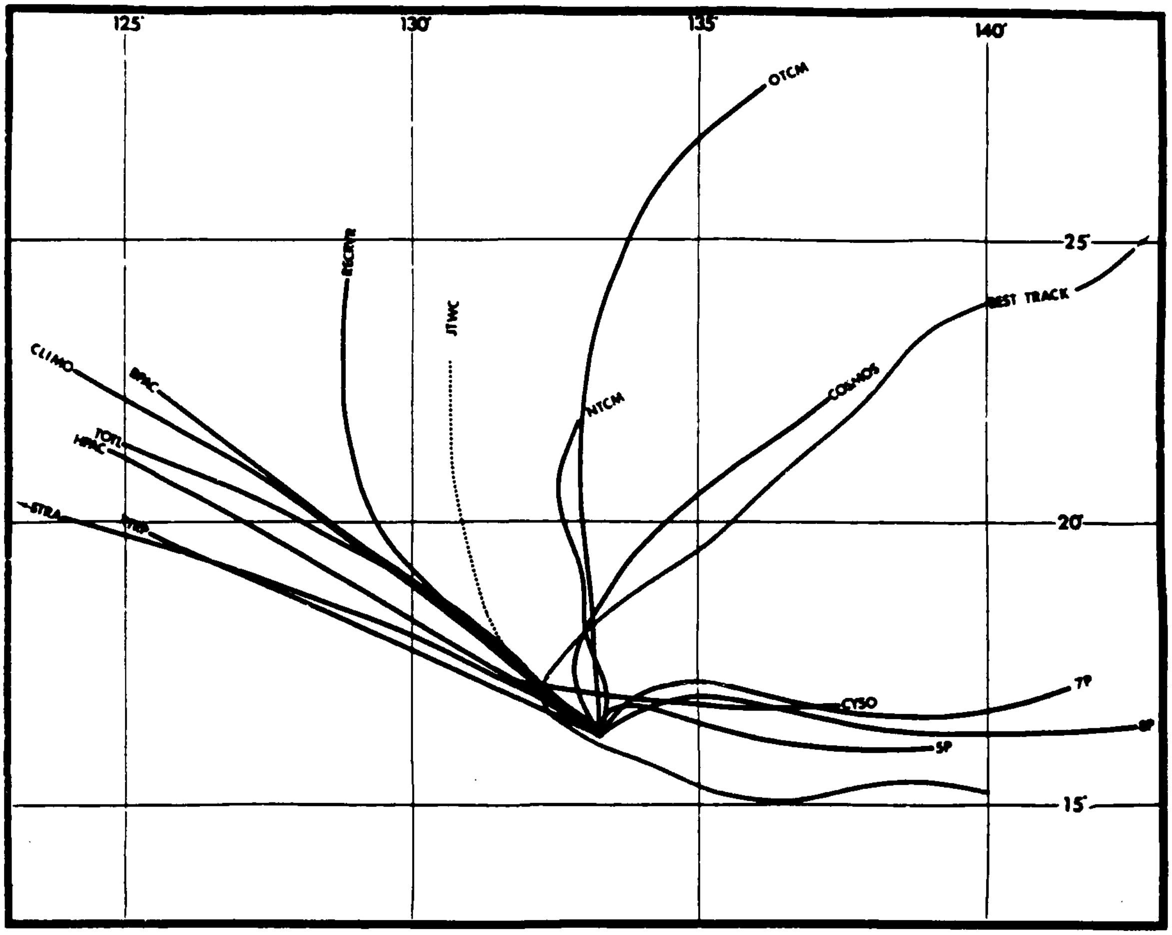


Figure 1. The Standard Array of JTWC's Objective Forecast Aids to Support the 83081912 Warning for Tropical Storm Dom.

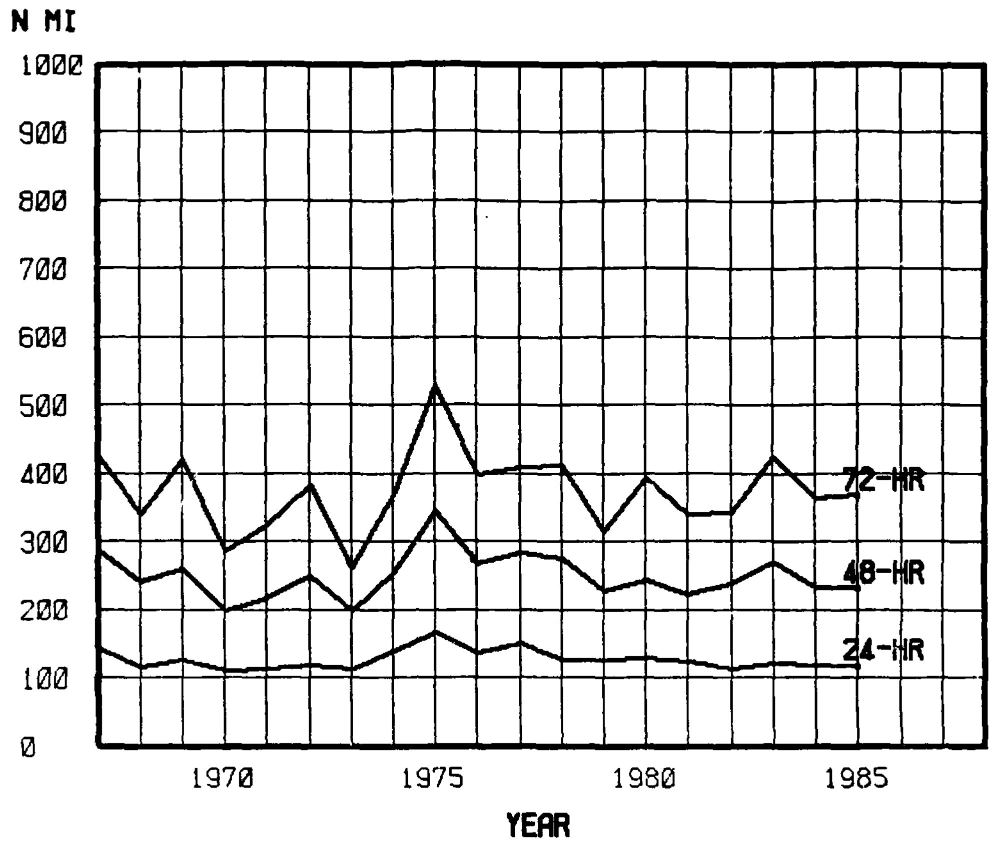


Figure 2. Annual JTWC Forecast Errors for All Tropical Cyclones in Western North Pacific Region. (JTWC began its 48-hr forecasts in 1959 and 72-hr forecasts in 1962.)

1981), as shown in Figure 1. As in a tropical cyclone warning situation, where time is limited, choosing from 26 different objective aids could be a formidable task for the forecaster.

To assist forecasters in understanding more about these aids, so that some logical selection procedure may be realized, Tsui (1984) inter-compared the JTWC official and objective aid forecasts. He found that the Nested Tropical Cyclone Model (NTCM), although lacking speed, provided good guidance in the heading of the storm. He also found that blending of Half Persistence and Half Climatology (HPAC) gave amazingly good 72-hr forecast guidance. Elsberry and Peak (1986) used the cross-track and along-track concept to evaluate the aids and ranked the One-way Interactive Tropical Cyclone Model (OTCM) as the top aid for the 1979-83 period because it provided an excellent directional change forecast. They found, however, that when OTCM errs it would most likely be in the degree of directional change, not in the sign of the directional change. Also, Elsberry and Peak discovered that the HPAC technique possesses some measurable skills.

Tsui (1984) demonstrated that if the "correct" guidance is chosen consistently, the 24-, 48-, and 72-hr forecasts would improve by 47%, 53%, and 56%, respectively. "Correct" means that the forecast track of an objective aid produces the least forecast errors. The forecast error is defined as the shortest distance between the verified and the forecast positions. Since some of the errors refer to the randomness of the tropical cyclone motion, the 56% error reduction for a 72-hr forecast can never be realized. This does not detract from the fact that there is still room for improvement among existing aids, however. Of course, the level of improvement depends on how well we know when and how to follow an aid's guidance.

Peak and Elsberry (1985) used a "decision-tree" approach to find the best forecast guidance among three analog techniques. They showed that a "decision-tree" analysis can help the forecasters to select the "correct" objective guidance. Elsberry

and Peak (1986) also showed that by knowing the biases of the aids with respect to the Climatology-Persistence (CLIPER) technique, a corrective scheme can be developed to improve JTWC's forecasts. It has become increasingly clear that the key to improve tropical cyclone forecasts in the near future is to improve the utilization of the aids, not necessarily to improve the objective aids themselves.

This report summarizes the results of a comprehensive review about the performance of all JTWC operational objective tropical cyclone forecast aids during the eight year period, 1978-1985. Also, it will identify the characteristics of the operational performances of these aids and attempt to suggest methods to improve the utilization of objective aids.

2. JTWC TROPICAL CYCLONE OBJECTIVE FORECAST AIDS

As discussed by Neumann (1985), objective tropical cyclone prediction aids can be classified as a numerical model type or a statistical type. Within these two types, there are six subdivisions of models. A complete description of all 26 tropical cyclone objective forecast aids available to the JTWC forecasters is beyond the scope of this report. According to Neumann's classification, however, a brief introduction of these aids is warranted to provide a background for the following discussions. A summary list of the Neumann classification of JTWC objective aids is given in Table 1.

2.1 Analog Method.

The analog program is a climatological/statistical forecast model. The skill of this model relies on the premise that there are families of tropical cyclone tracks associated with repetitive and recognizable large-scale weather patterns (Neumann, 1985). This premise is supported by the fact that much of the variance of tropical cyclone motion is explained by seasonal variations. The analog model accepts current tropical cyclone positions, past movements, and other storm characteristics, and

Table 1. JTWC tropical cyclone objective aids summary.

1. Analog Method:
   RECR, STRA, TOTL
2. Climatology-Persistence Method:
   CLIM, XTRP, HPAC, CLIP
3. Synoptic-Statistical Method:
   CY20, CY30, CY50, CY70, CY85, CY10
4. Dynamic-Statistical Method:
   CY20, CY30, CY50, CY70, CY85, CY10, CSUM, COSM
5. Barotropic Model: (None)
6. Baroclinic Model:
   OTCM, NTCM

compares these parameters to those of the past tropical cyclones within the same geographic area (3 x 3 degree area) and within the same month. All storms with a certain amount of similarity to the current storm are weighted and summed to provide a 24-hr forecast position. The procedure is repeated (Jarrell and Wagoner, 1973) to obtain the 48- and 72-hr forecasts.

Depending on the data base, the analog technique produces three separate forecasts. The prediction based on the tracks of those historical recurving storms is called the "RECR" forecast. A recurving storm is defined as a storm that turns toward the north or northeast from an initial westward direction. The prediction based on the tracks of those historical straight moving (predominately westward moving) storms is called the "STRA" forecast. The prediction based on the entire data base is called the "TOTL" forecast.

2.2 Climatology/Persistence Method.

Despite the simplicity, the climatology combined with the persistence method has a surprisingly measurable forecast skill. The simplest program is the climatology program (CLIM). CLIM 24-hr forecast is generated by computing the average 24-hr

displacement of the past storms. These past storms are located within a 3 x 3 degree area of the current storm and within the same month. To obtain the 48- and 72-hr CLIM forecasts, the procedure is repeated. The climatology data base is the same data base used by the analog objective aid TOTL. Through years of experience in using CLIM as a guidance, JTWC forecasters discovered that a tropical cyclone's movement is influenced consistently by the motion of the storm away from the climatology track. Hence, the simple "Half Persistence and Climatology" (HPAC) forecast method was developed. HPAC forecast is simply the average of the CLIM and persistence forecasts. The persistence forecast is called XTRP for "extrapolation" and is produced by extending the immediate past 12-hr storm motion for 24, 48, and 72 hours.

To capitalize on the success of HPAC, two variations of HPAC have been developed. TPAC differs from HPAC only in the 72-hr forecast which is composed of three parts of climatology and one part of persistence. The Blended Persistence and Climatology (BPAC) forecasts are different from HPAC forecasts in that the CLIM forecasts are weighted more toward the 72-hr forecasts. In addition, direction and speed of the storm can heavily influence the weights between CLIM and XTRP. This aid was developed by JTWC forecasters who intended to capitalize on the success of the climatology/persistence technique.

Another type of the climatology/persistence program is the CLIPER regression model. A cubic polynomial regression equation for the western North Pacific region called CLIP was developed by Xu and Neumann (1985). CLIP uses eight predictors which includes the current storm motion, location, intensity, and past storm motion.

2.3 Statistical Method.

The statistical programs can be divided into two types: Synoptic-Statistical Programs and Dynamic-Statistical Programs. Typically, both programs are regression models and usually

include persistence, climatology, and atmospheric forcing variables as predictors. The difference between the two is that the Synoptic-Statistical models derive the atmospheric forcing terms from synoptic analysis fields and Dynamic-Statistical models derive their forcing terms from dynamic produced forecast fields. JTWC has both types.

CYCLOPS, developed by Renard (1968, 1973), uses geostrophic winds as the forcing to steer storms. The geostrophic wind is derived from a smoothed geopotential height field. When a 500 mb height field is used, the forecast is called CY50. In total, seven height fields (1000, 850, 700, 500, 400, 300, and 200 mb) are used by CYCLOPS. In addition, two versions of the CYCLOPS are available to JTWC forecasters: the forecasts made by using the geostrophic winds derived from the analysis fields, and those derived from the prognostic fields. Hence, CYCLOPS is both a synoptic- and dynamic-statistical program that provides a total of 14 forecasts to JTWC forecasters.

CYCLOPS forecasts aids are the least satisfactory in comparison to other objective aids; however, these aids (especially CY85, CY70, and CY50) are routinely used by the forecasters as tools to identify the synoptic scale features. Since CYCLOPS forecast tracks are the direct reflections of steering currents, experienced forecasters can use these tracks for measuring the vertical wind shear, changes in steering at various level, and depth of weakness of the sub-tropical ridge. In quantifying these synoptic measures, Allen (1984) developed a model output statistics technique called "COSM." COSM combines the 72-hr forecasts of CY85, CY70, and CY50 through regression equations to yield the COSM 72-hr forecast position. Then the 48-hr and 24-hr positions are derived by a linear combination of persistence and straight line interpolation between the current and 72-hr position.

Matsumoto (1984) developed a dynamic-statistical model called "CSUM" and is currently available to JTWC forecasters as an objective forecast aid. The methodology of CSUM is very

similar to NHC73 (Neumann and Lawrence, 1975). Instead of developing the regression equation for the entire basin, CSUM develops a regression equation for each of the three sub-basins. The sub-basins, in relation to the subtropical ridge, are delineated according to the storm's position: north of the ridge, on the ridge, and south of the ridge.

2.4 Numerical Models

Neumann (1985) divided the numerical models into barotropic models and baroclinic models. Among the JTWC aids, there are two baroclinic models. One-Way Interactive Tropical Cyclone Model (OTCM) is a coarse mesh, three layer primitive equation model with a 205 km grid spacing over a 6400 x 4700 km domain (Harrison and Elsberry, 1972, Ley and Elsberry, 1976, Hodur and Burk, 1978). A symmetric tropical cyclone is bogused into 850 mb wind fields. The tropical cyclone's vicinity winds are smoothed. The storm's past motion is somewhat adjusted to the initial steering field. The boundary wind components normal to the boundary is adjusted so that no net divergence exists in the domain. The one-way interactive boundary condition is updated every 12 hours by the prognostic fields of the Navy's operational global weather prediction model (NOGAPS).

Similarly structured to that of the OTCM is the Nested Numerical Tropical Cyclone Model (NTCM). The NTCM differs by containing a finer-scale mesh which is nested in the coarse grid (Harrison, 1981, Harrison and Fiorino, 1982, Fiorino and Harrison, 1982). Early versions of NTCM are initialized by the analysis fields and runs independent of the large-scale model prognostic fields. The finer-scale mesh (41 km) covers a 1200 x 1200 km area and keeps the tropical cyclone at its 850 mb center. The 1984-85 version runs with the updated boundary conditions from NOGAPS and the area coverage is much larger.

3. DEFINITIONS AND ERROR MEASURES

3.1 Definitions

Before the error measures are described, definitions of three terms used in this study should be explained. These are best track positions, initialization positions, and warning positions. The best track positions are synonymous with the verified positions. The "best track" is a subjectively smoothed storm track and is produced in the post storm analysis when all available information is present and screened. The other two positions are produced every 6 hours (Warning time). Similar to the best track positions, these positions are also determined subjectively. The positions, however, are determined by using only the information up to the time when forecasters are preparing the warnings.

Since all objective aids are located at the Fleet Numerical Oceanography Center (FNOC) in Monterey, CA, JTWC forecasters will usually request that FNOC provide all objective aids at least 2 hours before a forecast warning is prepared. For example, a fore caster would normally prepare the 12Z warning between 12Z and 14Z, and issues the Tropical Cyclone Warning at or before 14Z. This current 12Z storm position is called the warning position. When forecasters activate the objective aids at 10Z, they are initialized with the 06Z storm position; these aids produce 24-, 48-, 72-hr forecasts from 06Z. This 06Z storm position is called the initialization position.

Since the initialization position is determined in the latter part of a warning cycle, when new storm position fixes are available, it should be closer to the best track position. As indicated above, the initialization position is determined 4 hours after 06Z and the warning position is determined, at most, 2 hours after 12Z. In this comparison study, the JTWC official 12Z forecast is compared with the aid's forecast initialized at 12Z. Hence, the objective aids have a 2 hour advantage over the JTWC forecasters in getting the most recent information. On the other hand, forecasters have the advantage of referring to the

objective aids while making their forecasts. The practice of using time variations for comparing official forecasts to the objective aid forecasts is recognized as "fair" and "acceptable."

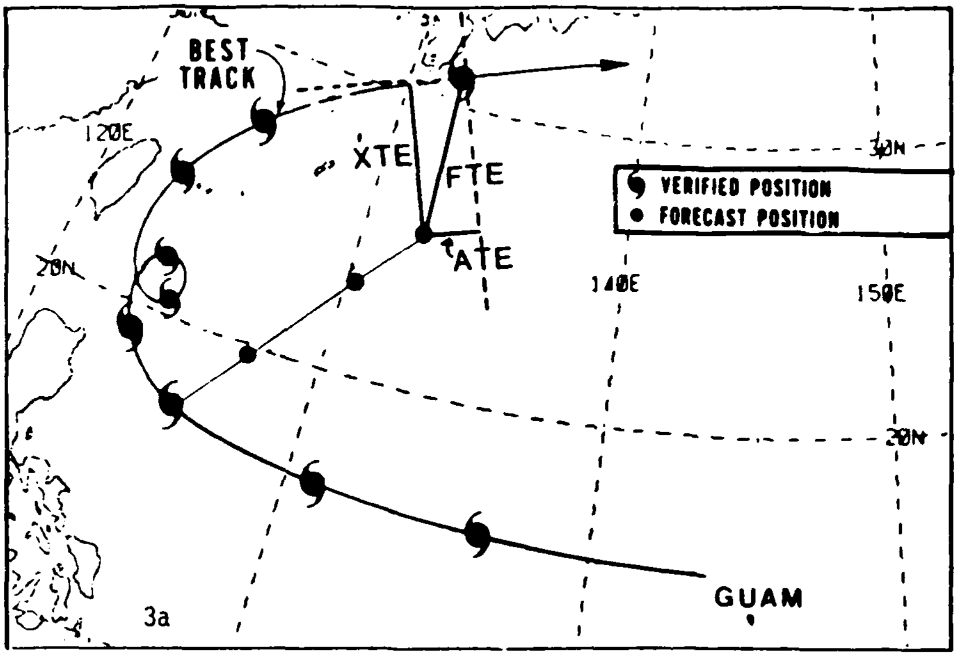
Before 1983, JTWC forecasters issued the warnings on or before 00Z, 06Z, 12Z, and 18Z, so the time discrepancy increases to about 4 hours.

3.2 Error Measures

The most frequently used tropical cyclone forecast verification measure is forecast error (FTE), which is defined simply as the shortest distance between the forecast and verified positions (Figure 3a). As discussed by Neumann and Pelissier (1981), FTE is not an absolute objective error measure because the verified position is extracted from the best track. Since no other overall error measure is as flexible, however, FTE still remains the most popular forecast verification measure.

To supplement FTE in investigating the characteristics of the objective aids' performance, two other error measures are used in this study: cross-track error (XTE), and along-track error (ATE). Shapiro and Neumann (1984) have shown that these two error components together are better than the popular FTE for error measure. XTE and ATE are two components of FTE (Figure 3a) decomposed in a natural coordinate system. The coordinates' origin is placed on the verified position, and the instantaneous motion vector is the motion vector of the best track. XTE indicates how accurate the forecast track is with respect to the best track. Positive XTE and ATE of a forecast means the forecast is off to the right and ahead of the corresponding best track position.

Three additional common error measures, computed for comparison purposes, are tabulated in the appendix. These errors are track error (TKE), speed error (SPE), and timing error (TME). TKE is the shortest distance to the track and is usually perpendicular to the best track (Figure 3b). When forecast positions reach beyond the end of the best track, the TKE



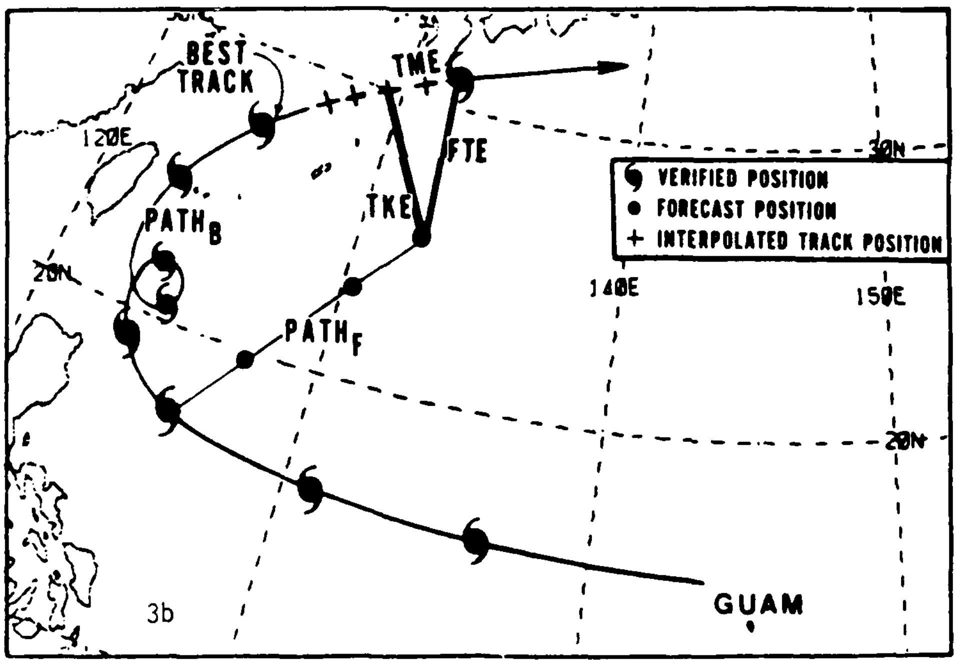


Figure 3. (a) Schematic Diagram for Forecast Error (FTE), Cross-Track Error (XTE), and Along-Track Error (ATE). (The instantaneous motion vector of the natural coordinate system is the motion vector of the best track of the immediate past hour.)
(b) Schematic Diagram for Track Error (TKE), Speed Error (SPE), and Timing Error (TME). (SPE is defined as the difference between the forecast path (Path F) and the best track (Path B) divided by the forecast period.

becomes the shortest distance between the forecast position and the last verified position. For the sake of simplicity, the track error is computed in this study by measuring the shortest distance between the forecast position and the hourly best track position. The hourly best track positions are estimated through the interpolation scheme devised by Akima (1970). Positive TKE indicates the forecast position is to the right of the best track. Unlike XTE, TKE is not an independent error measure. It depends on the forecast speed - the slower the movement, the smaller the TKE. Hence, TKE and the speed of the storm must be evaluated together.

As shown in Figure 3b, SPE is the speed difference between the storm traveling along the best track (Path B) and that of the forecast track (Path F). Path B begins at the best track position while Path F starts at the initialization position. A positive SPE indicates the forecast storm speed is faster than what is verified. In addition to TKE and SPE, TME evaluates the timeliness of the forecast. It is the time difference between the verified time and the forecast time projected by the TKE (Figure 3b).

All errors are compiled in terms of mean, standard deviation, and median. The median is estimated through a gamma probability distribution. The gamma distribution's shape and size parameters are estimated by the data sample through the Maximum Likelihood Function. With large sample sizes, the estimated gamma median approaches the true median.

3.3 F Test

The analysis of variance (F Test) used in this study detects whether a particular forecast aid is significantly different than other aids. For example, if an aid producing the smallest forecast error has a mean FTE value that is significantly different (95%) from that of the next aid, do the following. First, all techniques in the comparison are ranked by their mean FTE values.

The mean, standard deviation, and sample size are considered if an F Test detects that a technique is significantly different from others. The technique with the largest mean FTE is discarded from the group. The F Test is repeated until the techniques are similar to one another. If there is only one technique left in the last group, then it is the best technique to produce the smallest mean FTE; however, if there is more than one aid left in the last group, the difference among these aids is judged as not statistically significant at the preset significance level. In this study, all F tests are set at 5% significance level.

4. DATA

Along with all official forecasts and best track information, JTWC has retained all objective aid forecasts used in tropical cyclone warnings since 1978. These data records are stored on the computer mass storage system at FNOC. Each record contains the six hourly storm 24-, 48-, and 72-hr forecast locations, the warning position, and the official forecast positions and intensities (central surface maximum wind speed). The six hourly best track locations and intensities are stored in a separate file.

The 72-hr XTRP positions in this study are computed from the XTRP 24- and 48-hr positions, since only 24- and 48-hr XTRP positions are saved on the FNOC record. Hence, the 72-hr HPAC and TPAC positions are also computed. BPAC will not be examined in this study because the BPAC is no longer an active objective aid at JTWC. In addition, since not all CYCLOPS forecasts are saved, only CY50 and CY70 forecasts are studied for comparison purposes.

Recent aids introduced after 1984 will not be examined because of the small sample size. COSM and CSUM were installed recently, so they will be included in the study for those years when data are available. COSM was installed before 1984's

typhoon season, and CSUM was installed in September 1985. NTCM will not be fully examined because of the yearly change of the model. Several drastic changes have been made to the model since 1980, and the characteristics of the model performance of one version cannot represent that of the other. In this study, only the 1985 version of the NTCM will be studied.

5. EVALUATION OF OFFICIAL AND OBJECTIVE AID FORECASTS (1978-85)

Since the requirement for Naval evasion operations depends on the accuracy of the long range forecast, the emphasis of this report will be placed on the 72-hr forecast verification. Unless otherwise noted, all comparisons of and references to, forecast errors will be those of the 72-hr forecast.

5.1 JTWC Performance

As mentioned in Section 1, tropical cyclone forecast skills have improved slightly since 1970. Figure 2 shows that this still holds true for JTWC. However, to determine if JTWC possesses skill in its forecasts or has improved its skill level, the variation in forecast difficulty from year to year must be removed. A good indicator of the forecast difficulty of a storm is the climatology/persistence model CLIP (Neumann 1981b). Figure 4 shows the difference of mean FTE between CLIP band JTWC for 72-hr forecasts. Positive values indicate that JTWC is better than CLIP or possesses measures that are consistent throughout the years. The "bi-yearly saw-tooth" effect (Jarrell et al., 1978) still appears to be playing a role in JTWC's forecast accuracy.

5.2 Forecast Aids Comparison

The FTE statistics for all objective aids during the eight year period (1978-85) are shown in Table 2. All error statistics compiled yearly are found in the appendix. An "F Test" shows that the top 5 techniques, including JTWC, are significantly better than the others but not different from one another ($F=1.3449$, $F_c=2.3729$). Fc is the critical F value for the 95%

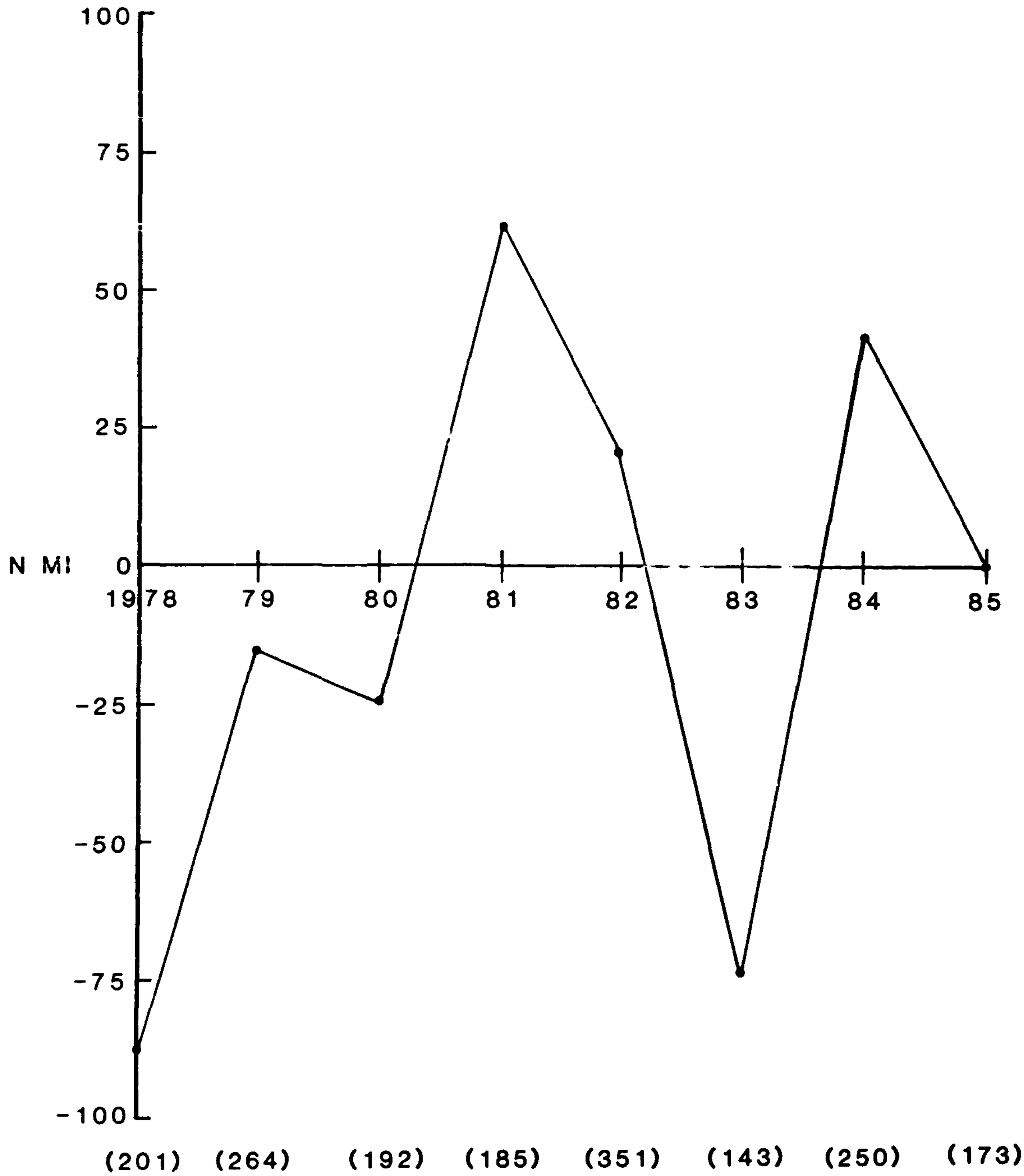


Figure 4. The difference of 72 hr FTE between JTWC and the objective aid CLIP. Positive values indicate that JTWC's performance is superior to CLIP's performance.

Table 2. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr forecast error (FTE) for JTWC official and objective aid forecasts during the 1978-85 period. (Units: n mi)

FTE 1978-1985

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
HPAC	125.1	241.9	358.6	80.7	153.9	229.2	123.5	238.6	352.7	3925	3121	1969
JTWC	120.6	240.2	361.9	77.6	153.3	236.6	119.1	237.0	355.6	4073	3125	2310
OTCM	125.9	238.1	362.1	79.5	145.3	218.0	124.3	235.1	356.6	2282	1787	1227
CLIP	117.8	244.7	369.8	76.1	150.6	229.0	116.3	241.5	363.9	3112	2544	1988
TPAC	125.1	241.9	373.1	80.7	153.9	236.8	123.5	238.6	366.9	3925	3121	1969
TOTL	126.6	253.3	384.2	81.4	156.6	239.2	125.0	249.9	377.9	3752	3041	2384
COSM	124.3	242.6	386.0	80.9	151.3	231.8	122.6	239.4	380.1	952	750	562
RECR	131.5	258.2	393.8	84.0	150.8	230.7	129.8	255.0	387.9	3627	2930	2302
CLIM	161.7	298.1	425.1	99.4	181.4	263.1	159.7	293.9	417.7	3991	3182	2018
STRA	139.0	290.9	426.6	96.9	209.4	300.2	137.1	285.7	417.5	2581	2169	1738
XTRP	130.6	279.8	442.7	88.9	182.5	278.4	128.8	275.7	434.6	3991	3191	2500
CY70	148.4	295.8	451.4	100.5	178.5	268.2	146.5	291.7	443.8	1544	1215	890
CY50	140.4	303.7	490.2	97.6	199.2	335.3	138.5	299.0	479.5	2753	2204	1658

Significance Test. It was good to find that JTWC, compared to any other objective aid, performed very well for the 24-hr forecast. Note that all three of the climatology/ persistence models are included in the best technique group. With the standard deviation of 218 n mi, OTCM's technique is more consistent than its competitors whose standard deviations are around 230 n mi.

Statistics for XTE and ATE are provided in Tables 3 and 4, respectively. The F Test indicates that the HPAC is significantly better than all other aids (F=3.2705, Fc=3.8448) in terms of the XTE, while OTCM is the best technique (F=1.4062, Fc=3.8441) when considering ATE. Table 4 shows the slow bias of all aids and the official JTWC forecasts, where all median values are negative. The results are consistent to the findings of Tsui (1984). Although NTCM was considered by Tsui as the best aid for the heading direction, it was also recognized that the extremely slow speed bias was partially responsible for NTCM's provision of good heading guidance. OTCM is the best aid for the speed forecast. JTWC clearly recognizes that all aids are slow (negative ATE median values) and attempts to compensate for the slowness in the official forecasts.

The HPAC technique is a simple average of the CLIM and XTRP forecasts. It was created because JTWC forecasters had long suspected that the verified tropical cyclone track usually fell between these two techniques (Figure 5). But the median XTE for HPAC shows a forecast bias to the left (median = -12.9 n mi meaning favoring XTRP), while TPAC is to the right (median = 14.1 n mi meaning favoring CLIM). Therefore, it appears that HPAC could be improved if the CLIM forecast was weighted more than 1/2 and less than 3/4. A sensitivity test, however, made by varying the weights of the CLIM and XTRP forecasts, show that the current 1:1 ratio gives the lowest mean FTE for the entire eight year period. Both OTCM and JTWC have the best speed guidance; but OTCM seems to produce better 72-hr speeds and JTWC is excellent in estimating the 24-hr movement. Although RECR has a poor mean ATE, its relatively low median shows that at times it has some value.

Table 3. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr cross track error (XTE) for JTWC official and objective aid forecasts during the 1978-85 period. (Units: n mi)

XTE 1978-1985

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
HPAC	69.8	132.9	202.8	87.6	169.5	257.9	-18.6	-24.9	-12.9	3925	3121	1969
JTWC	71.9	141.8	216.6	92.2	183.0	280.9	-15.8	-21.4	-30.8	4073	3125	2310
CLIP	67.0	141.7	221.2	85.9	182.7	278.5	-8.8	-2.5	15.8	3112	2544	1988
TPAC	69.8	132.9	223.2	87.6	169.5	285.3	-18.6	-24.9	14.1	3925	3121	1969
COSM	58.7	123.7	225.4	74.1	145.7	244.8	15.5	51.7	119.9	952	750	562
OTCM	68.6	139.7	228.2	86.1	175.1	286.2	-8.2	-22.9	-42.6	2282	1787	1227
TOTL	78.5	150.9	229.0	98.7	187.3	288.0	-20.8	-47.4	-54.6	3752	3041	2384
CY70	87.3	154.0	240.8	113.8	199.6	307.7	-17.7	-1.7	46.7	1544	1215	890
XTRP	75.2	157.0	245.9	94.3	195.6	306.7	-28.9	-62.1	-79.9	3991	3191	2500
RECR	77.9	156.0	246.8	99.5	194.9	300.1	7.0	26.5	69.9	3627	2930	2302
STRA	86.9	173.0	254.7	104.5	202.9	302.4	-43.1	-105.2	-146.5	2581	2169	1738
CLIM	94.4	178.1	267.9	120.3	227.1	338.8	-9.1	8.6	39.0	3991	3182	2018
CY50	84.4	173.1	282.5	112.3	235.9	388.3	-13.2	11.7	45.5	2753	2204	1658

Table 4. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr along-track (ATE) for JTWC official and objective aid forecasts during the 1978-85 period. (Units: n mi)

ATE 1978-1985

TECH	MEAN			STDEV			MEDIAN			COUNT		
	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	90.8	161.4	230.9	106.1	205.6	298.9	-61.1	-73.6	-93.0	2282	1787	1227
JTWC	80.9	162.2	239.3	101.9	202.4	305.6	-40.7	-86.6	-132.9	4073	3125	2310
TPAC	89.1	173.7	251.2	103.4	199.1	296.4	-61.6	-121.8	-172.7	3925	3121	1969
CLIP	82.7	169.7	251.9	99.8	199.3	305.1	-49.7	-103.1	-147.6	3112	2544	1988
HPAC	89.1	173.7	252.0	103.4	199.1	293.1	-61.6	-121.8	-182.0	3925	3121	1969
TOTL	83.1	170.1	254.6	105.1	208.9	314.9	-41.3	-96.8	-158.6	3752	3041	2384
RECR	90.1	174.6	257.6	111.4	212.2	320.4	-46.5	-80.2	-110.4	3627	2930	2302
COSM	97.4	182.3	269.7	103.6	196.6	306.5	-76.2	-143.1	-194.4	952	750	562
CLIM	111.7	202.9	273.6	130.7	241.4	332.7	-69.5	-116.6	-164.3	3991	3182	2018
STRA	89.9	191.4	278.0	115.1	251.8	369.2	-56.1	-127.8	-183.2	2581	2169	1738
XTRP	90.4	197.0	315.0	112.6	236.3	374.1	-54.3	-127.9	-207.0	3991	3191	2500
CY50	94.0	208.5	328.7	118.3	236.3	385.7	-52.8	-150.0	-246.2	2753	2204	1658
CY70	101.7	219.9	331.5	124.5	247.1	371.1	-61.6	-144.2	-219.3	1544	1215	890

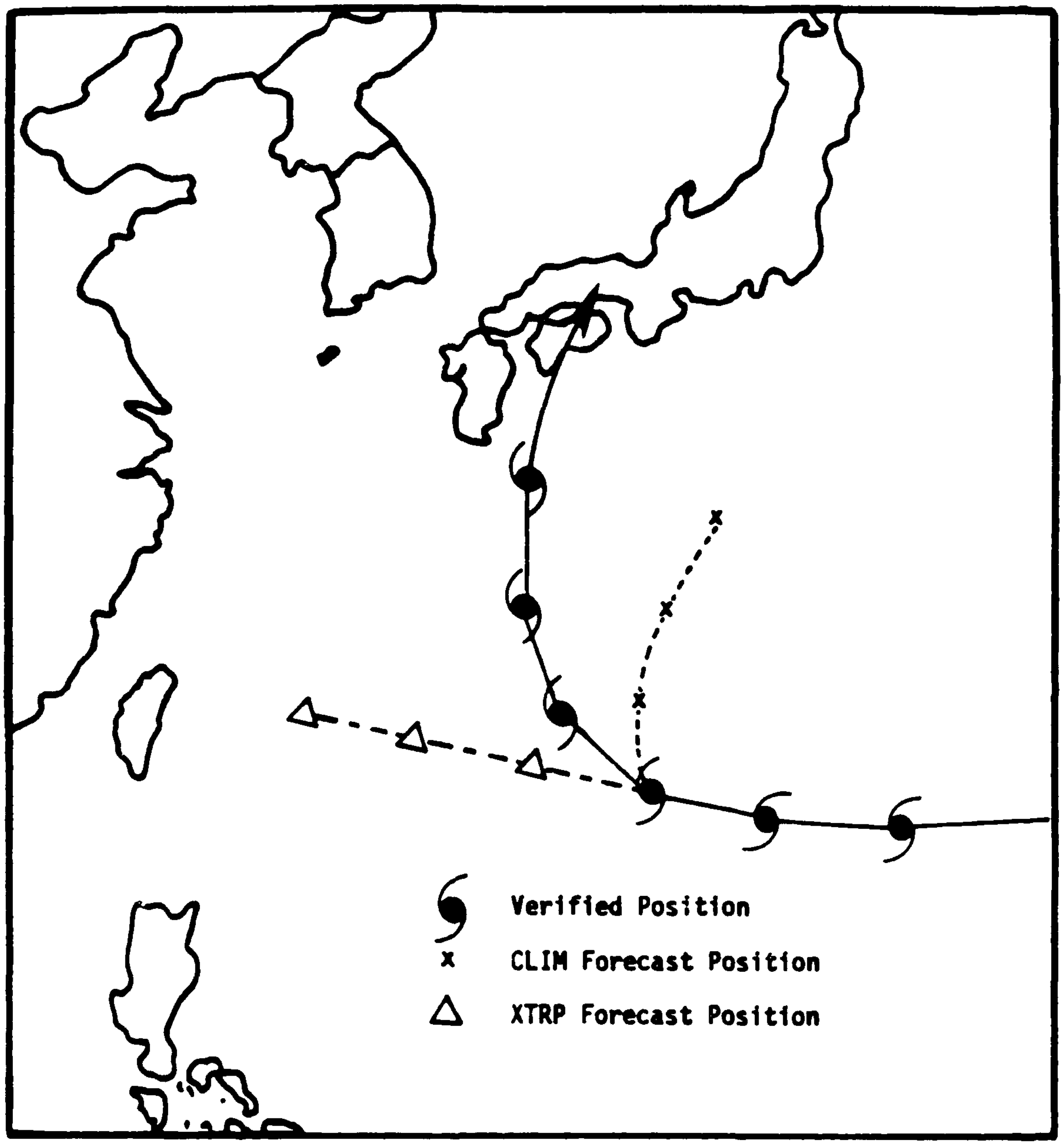


Figure 5. Schematic Diagram for the Best Track Falling Between the Climatology (CLIM) and Persistence (XTRP) Forecasts.

5.3 Year-to-Year Variability

In order to examine the consistency of a technique's performance from year to year, the F Test is used. Table 5 presents the best techniques of each year (denoted by an "x"). The yearly FTE's are compared through the F Test for a given forecast period (TAU). When aids are considered to be the best techniques of the year, this indicates that the difference of the FTE mean values among these techniques are not statistically different at the 5% significance level. The bottom of Table 5 shows the percentage of years when a technique was considered to be the best. For example, six out of eight years (75%), OTCM is a top technique for the 72-hr forecast. The results show that JTWC, OTCM, and the three climatology/ persistence models are the most consistent and reliable forecast techniques. The overall eight-year performance of these techniques (see Table 2) was not due to an abnormally "excellent" year, but rather a consistent "good" performance every year. One cannot fail to note that while XTRP and CLIM do very poorly from year to year, their average (HPAC) does amazingly well year after year.

Since COSM was developed in 1983, JTWC has only seen it for two years. Though the long-term performance characteristics of the technique cannot be determined from the two-year record, COSM certainly appears to be a reliable forecast technique.

Table 6 presents the year-to-year XTE variation which represents the accuracy in providing the storm heading direction guidance. Unavoidably, one would notice that HPAC provides the best directional guidance in 72-hr forecasting. Combining the consistency of HPAC, TPAC, and the median values shown in Table 3, one can suggest that the storm track consistently falls between the HPAC and TPAC forecasts, and closer to HPAC than TPAC.

Table 7 shows the year-to-year ATE variation of the objective aids category. OTCM consistently gives the best speed guidance. This agrees with the statistics shown in Table 4.

Table 5. Year-to-year comparison of FTE among JTWC official and all objective aids (units are n mi). An X denotes the aid has been judged one of the best aids in the category. The - denotes no data available in the category. Percents at bottom of table indicate percentage of years the aid has been considered to be the best aid.

TAU	YR	JTWC	OTCM	STRA	RECR	TOTL	CLIM	XTRP	CLIP	COSM	CY70	CY50	HPAC	TPAC
	78	X							X	-				
	79	X	X			X			X	-			X	X
	80	X	X	X	X	X			X	-	X	X	X	X
24	81	X	X	X	X	X		X	X	-	-	X	X	X
	82	X		X	X	X		X	X	-	-	X	X	X
	83	X	X		X	X		X	X	-	-	X	X	X
	84	X	X	-	X	X		X	X	X	-	-		
	85	X	X	-		X		X	X	X	-	-	X	X
	78	X			X	X			X	-			X	X
	79	X	X		X	X			X	-			X	X
	80	X	X		X	X			X	-	X	X	X	X
48	81	X	X							-	-			
	82		X			X				-	-		X	X
	83		X		X			X	X	-	-		X	X
	84	X	X	-					X	X	-	-		
	85	X	X	-		X			X		-	-	X	X
	78		X		X	X	-		X	-			-	-
	79	X				X	X		X	-			X	X
	80	X	X		X	X			X	-	X	X	X	X
72	81	X	X							-	-		X	
	82	X	X			X			X	-	-		X	X
	83				X		X	X	X	-	-		X	X
	84	X	X	-						X	-	-		
	85	X	X	-		X		X	X	X	-	-	X	X
TOTAL (%)														
24		100	75	50	63	88	0	63	100	100	33	66	75	75
48		75	88	0	50	50	0	13	75	100	33	17	75	75
72		75	75	0	38	50	29	25	75	100	33	17	86	71

Table 6. Year-to-year comparison of XTE among JTWC official and all objective aids (units are n mi). An X denotes the aid has been judged one of the best aids in the category. The - denotes no data available in the category. Percents at bottom of table indicate percentage of years the aid has been considered to be the best aid.

TAU	YR	JTWC	OTCM	STRA	RECR	TOTL	CLIM	XTRP	CLIP	COSM	CY70	CY50	HPAC	TPAC
	78	X							X	-			X	X
	79	X	X						X	-			X	X
	80	X	X			X			X	-			X	X
24	81		X						X	-	-		X	X
	82									-	-		X	X
	83		X							-	-	X		
	84			-						X	-	-		
	85			-						X	-	-		
	78					X			X	-			X	X
	79	X	X						X	-			X	X
	80									-	X	X	X	X
48	81	X	X			X			X	-	-		X	X
	82									-	-		X	X
	83		X					X	X	-	-		X	X
	84		X	-						X	-	-		
	85			-						X	-	-		
	78						-		X	-			-	-
	79									-			X	X
	80									-			X	
72	81		X	X						-	-			
	82	X	X							-	-			
	83		X				X	X	X	-	-		X	X
	84	X	X	-							-	-		
	85			-					-		-	-	X	
TOTAL (%)														
24		38	50	0	0	13	0	0	50	100	0	17	63	63
48		25	38	0	0	25	0	13	50	100	33	17	75	75
72		25	50	17	0	0	13	13	25	0	0	0	71	43

Table 7. Year-to-year comparison of ATE among JTWC official and all objective aids (units are n mi). An X denotes the aid has been judged one of the best aids in the category. The - denotes no data available in the category. Percents at bottom of table indicate percentage of years the aid has been considered to be the best aid.

TAU	YR	JTWC	OTCM	STRA	RECR	TOTL	CLIM	XTRP	CLIP	COSM	CY70	CY50	HPAC	TPAC
	78	X		X		X			X	-				
	79	X			X	X			X	-				
	80	X				X			X	-	X	X		
24	81	X								-	-			
	82	X				X			X	-	-			
	83	X	X		X	X		X	X	-	-	X	X	X
	84	X		-	X	X			X		-	-		
	85	X	X	-		X					-	-		
	78					X			X	-				
	79	X				X			X	-			X	X
	80	X	X		X				X	-				
48	81	X	X							-	-			
	82					X				-	-		X	X
	83	X	X		X	X	X	X	X	-	-		X	X
	84	X		-							-	-		
	85		X	-							-	-		
	78		X	X	X	X	-		X	-	X		-	-
	79	X			X	X	X		X	-			X	X
	80	X	X		X				X	-				
72	81	X	X		X					-	-			
	82		X							-	-			
	83		X				X			-	-		X	X
	84	X		-							-	-		
	85	X	X	-	X	X	X		X		-	-	X	X
TOTAL (%)														
24		100	25	13	38	88	0	13	75	0	33	33	13	13
48		63	50	0	25	50	13	13	50	0	0	0	38	38
72		63	75	13	63	38	43	0	50	0	0	0	43	43

From Tables 3, 4, 6, and 7, we conclude that, in general, the climatology/persistence aids give good directional guidance, while OTCM gives the best estimates of the storm's speed.

Tables 6 and 7 show that JTWC's speed forecasts are markedly superior to its track forecasts. There are several reasons for this difference in skill. The forecasters at JTWC already know that all of the objective aids have a slow storm speed bias. Thus, by simply increasing the storm speed of their forecasts they consistently beat the objective aids. The track forecast biases of the objective aids are not as well known and thus, no systematic correction can be made for them by JTWC.

In addition, JTWC faces the constraint to maintain continuity between forecasts. This can result in large track errors for several successive forecasts. An example of this is seen when the storm makes a rapid and unexpected change in its direction. In such a situation, the JTWC directional forecasts will lag behind the change for the next 12-24 hours in order to maintain continuity. The objective aids, however, have no such constraints and thus, can change their direction forecasts to give a more realistic storm track prediction.

5.4 Homogeneous Comparison

To compare the utility of the objective forecast aids of each technique type as shown in Table 1, we have selected one aid from each technique type to form a homogeneous data base for head-to-head comparison. The aids selected for comparison are the dynamic model (OTCM), analog model (RECR) and climatology/persistence model (HPAC), along with JTWC to form the homogeneous data base. Synoptic/Dynamic-Statistical model is not selected for the head-to-head comparison because of the small sample size of COSM and CSUM techniques and also, the poor performance of the CYxx type aids. For all eight years combined, OTCM, JTWC, and HPAC are better than RECR, but not significantly different from one another (F=1.5488, Fc=19.4954). Figure 6 shows the yearly mean for the 24- and 72-hr forecasts. All techniques

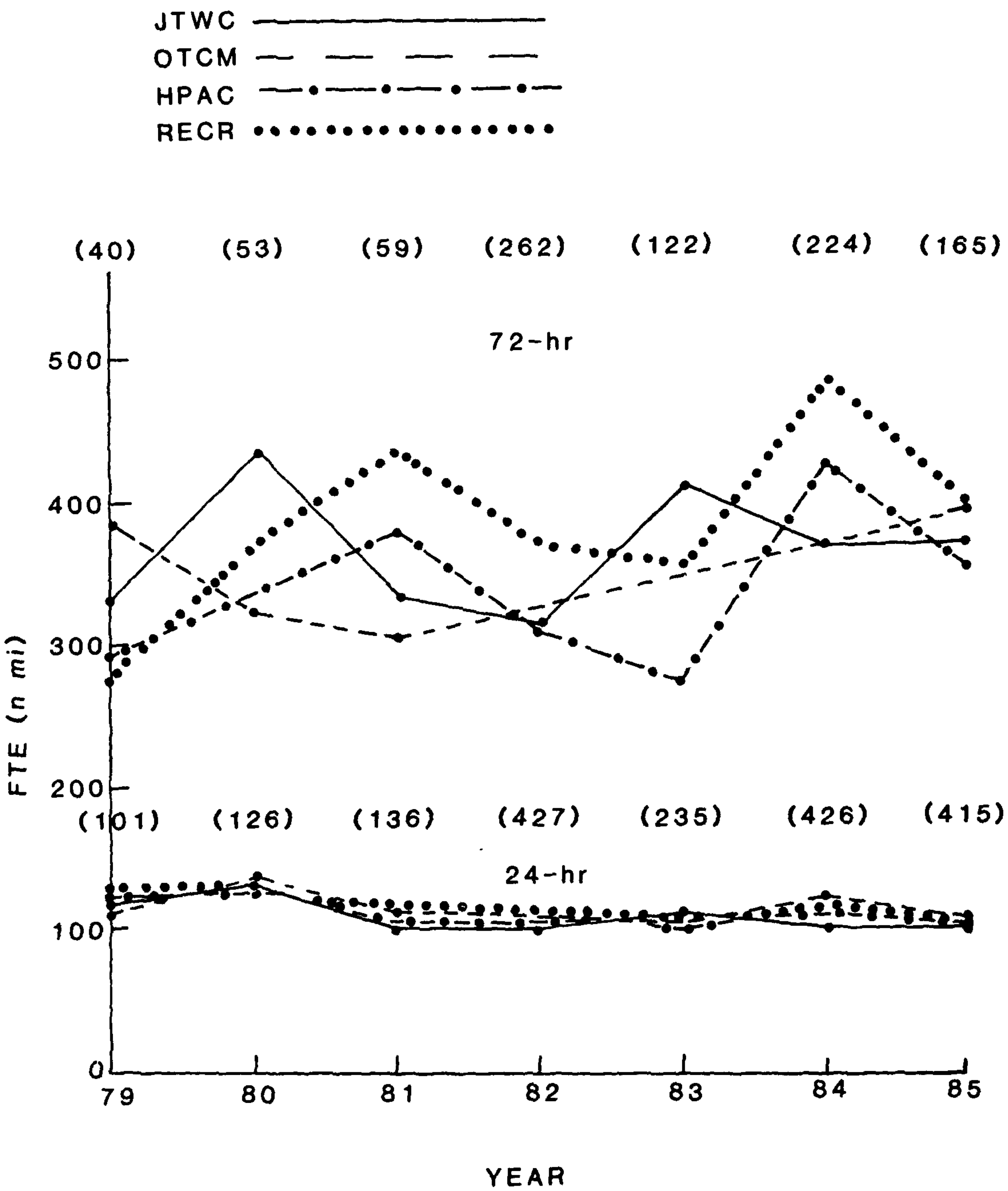


Figure 6. Homogeneous head-to-head comparison of 24 hr and 72 hr FTE among JTWC, OTCM, HPAC and RECR, 1979-85. The sample sizes are in parentheses.

are equal in short range forecasting. For 72-hour forecasts since 1980, either OTCM or HPAC have always been the best technique. Note that OTCM does not show the sharp year-to-year fluctuations like the other techniques. As expected, the RECR and HPAC are both depended on climatology; their year-to-year variations are similar, except RECR is worse than HPAC.

In a homogeneous head-to-head comparison of OTCM and HPAC, HPAC had a smaller mean FTE; but the F Test shows that it is not significantly better than OTCM (F=12.9005, Fc=254.2579). This comparison was also conducted for these two aids and JTWC. In both cases the objective aid had a lower mean than JTWC, but the difference was not significant (OTCM vs JTWC, F=4.5260, Fc=254.2561; HPAC vs JTWC, F=1.5909, Fc=3.8441).

Tsui (1984) points out that if the best objective aid for each forecast is always chosen, a 56% improvement over JTWC could be achieved. A similar computation using only OTCM and HPAC, shows that nearly half of this improvement (27%) is still possible even though only two aids are considered. This indicates that if we can just understand OTCM and HPAC well enough and know when to accept or reject one of the two aids, we can have a substantial improvement for 72-hr forecasts. Between these two aids, OTCM was selected half of the time (48%), thus demonstrating the fact that neither technique could be solely relied upon. Operationally, the JTWC forecaster still has to decide which technique provides the best forecast. This decision, however, between the two techniques should be much simpler than selecting one of 26 forecast aids. For example, if a storm has been behaving climatologically, it is likely that the HPAC guidance is best. When the synoptic situation is abnormal or the storm's movement is erratic, then OTCM should provide the best guidance. A scheme to extract the synoptic pattern (e.g., Elsberry and Peak (1986)) should be able to assist JTWC forecasters in determining when the is "normal" synoptic situation. From that determination, a decision can be made to follow the HPAC or OTCM guidance.

6. DATA STRATIFICATIONS

6.1 Recurving Types and Intensities

As previously discussed, each aid has its strengths and weaknesses. So far, no aid outperforms any other aid in all environmental conditions. For example, by definition, the XTRP aid cannot provide a reliable forecast guidance if the storm is recurving. For the same reason, we suspect that since the numerical models are always initialized with 60- to 105-kt intensities, the numerical models are deficient in providing good forecasts for tropical storms. In order to detect the strengths and weaknesses of the aids, the objective aids are compared in different types of situations. Storms are classified by its track and intensity characteristics and identified as a straight mover, a recurver, or an odd mover. If a storm's track is not a straight mover or a recurver, it is an odd mover that could be a looper. Also, a storm can be classified as either a tropical storm (35-63 kts), a typhoon (64-129 kts), or a super typhoon (greater than 129 kts).

In the straight moving category, Table 8 shows that the analog methods STRA and JTWC are by far the best forecast techniques (F=2.4134, Fc=3.8493). Although straight storms are among the easiest to forecast, the result is surprising because the persistence model XTRP was more than 80 n mi worse than STRA (the analog method gives more information other than extrapolation). Straight moving storms are of particular importance because a large percentage of them make landfall, while many recurving and odd moving storms stay well out to sea during their lives. JTWC appears to predict the straight moving storms better than most of the aids.

The best five techniques (COSM, RECR, CLIP, OTCM, and TPAC) at forecasting recurving storms (Table 9) are not significantly different (F=2.0090, Fc=2.3744). The poor performance of COSM in the straight mover category (Table 8) and its large XTE median (Table 3) makes one suspect that COSM's success is due largely to

Table 8. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr FTE for the straight moving storm category during the 1978-85 period. (Units: n mi)

STRAIGHT STORMS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
STRA	104.1	185.7	253.1	69.6	121.7	172.9	102.7	183.3	249.3	851	663	509
JTWC	102.8	189.8	269.6	64.7	125.1	187.2	101.5	187.2	265.2	1221	915	683
HPAC	103.3	190.6	280.4	63.7	114.2	162.8	102.0	188.3	276.8	1162	890	551
TOTL	105.3	192.5	235.6	67.6	113.9	167.6	103.8	190.3	281.9	1132	892	686
TPAC	103.3	190.6	322.6	63.7	114.2	197.5	102.0	188.3	318.0	1162	890	551
OTCM	119.9	216.6	329.5	65.4	119.6	195.6	118.6	214.2	324.8	640	496	353
XTRP	106.3	212.3	333.2	70.5	125.8	191.0	104.9	209.7	328.7	1190	922	706
CLIP	101.3	212.5	337.5	61.7	122.7	187.7	100.0	210.1	333.1	903	720	556
CLIM	140.2	264.2	399.4	83.2	157.9	237.5	138.5	260.7	393.2	1182	907	563
COSM	109.8	228.5	406.1	65.7	138.9	244.8	108.4	225.6	399.6	244	187	135
RECR	130.4	257.3	413.3	76.5	133.0	199.7	128.8	254.5	408.6	1089	858	658
CY70	143.4	284.0	422.1	88.1	157.8	218.2	141.6	280.5	416.6	426	305	196
CY50	128.2	282.4	440.1	86.2	174.6	273.5	126.4	278.5	432.2	860	659	468

Table 9. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr FTE for the recurving storm category during the 1978-85 period. (Units: n mi)

RECURVERS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
COSM	130.5	235.2	325.7	90.8	151.5	185.1	128.8	232.0	321.3	375	287	205
RECR	123.0	239.9	351.3	82.1	146.7	216.5	121.4	236.7	345.9	1696	1382	1082
CLIP	121.0	248.6	358.0	79.5	153.6	226.4	119.4	245.3	352.2	1459	1195	928
OTCM	130.3	244.2	362.2	90.0	158.3	221.3	128.6	240.8	356.6	978	750	465
TPAC	130.1	258.2	370.0	84.7	164.4	230.4	128.4	254.6	364.0	1802	1453	868
HPAC	130.1	258.2	381.9	84.7	164.4	245.8	128.4	254.6	375.3	1802	1453	868
JTWC	123.8	249.2	382.7	79.8	152.7	231.1	122.2	246.0	376.7	1875	1464	1082
CLIM	157.7	289.8	395.4	97.1	177.5	239.1	155.7	285.8	389.1	1829	1480	892
TOTL	128.4	266.4	405.3	80.7	162.4	252.8	126.8	262.8	398.4	1695	1382	1078
CY50	145.4	288.2	462.8	106.4	189.5	294.9	143.3	283.8	454.1	1312	1059	808
CY70	155.5	314.1	484.9	111.7	195.5	289.3	153.3	309.5	476.3	820	661	497
XTRP	143.8	312.9	487.3	96.6	203.7	310.1	141.8	307.9	477.7	1836	1485	1160
STRA	148.6	335.8	498.9	102.8	236.1	332.0	146.6	329.7	488.2	1162	1027	842

its consistent bias to recurve all storms. Although the mean FTE of HPAC is lower than that of TPAC overall (Table 2), TPAC shows a 11.9 n mi improvement over HPAC for recurving storms in Table 9. This is not surprising since in recurving situations, a 72-hr extrapolation forecast is very poor and HPAC weighs XTRP twice as much as TPAC does at 72-hrs.

The forecast techniques' performance on the remaining odd storms in the data base is very similar to their overall performance (Table 2) and thus is not presented here. The fact that STRA and RECR perform well on the types of storms they were designed for shows that the job of forecasting a tropical cyclone is largely a matter of determining whether or not a storm will recurve. Once this is known, these two analog models can provide good guidance. Almost a complete reversal of positions between Tables 8 and 9, points out that most techniques are only suitable for either straight movers or recurvers. The fact that HPAC and OTCM are not the best but the second best guides in either category, gives strength to an overall evaluation of these models (Table 2). Of course, we cannot ignore the fact that these two aids are the best aids for odd moving storms.

Storms are also classified according to their maximum intensity. The value of the human element in forecasting tropical storms is reflected in the statistics (Table 10). This table shows that JTWC easily outperforms the numerical model OTCM. JTWC forecasters do not depend solely on objective aids for guidance. They also question OTCM's forecasts of a tropical storm for the following reasons: 1) OTCM is initialized with a bogus typhoon intensity; 2) due to the lack of a well-defined circulation pattern, the storm's position fix for the model may not be as accurate as desired.

For the same reasons, objective aids that usually provide guidance for approximate forecast positions should do well in the tropical storm category. The simple analog and climatology/persistence models give better guidance than the dynamic model (Table 10). As expected, the OTCM shows a dramatic improvement

Table 10. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr FTE for the tropical storm category during the 1978-85 period. (Units: n mi)

TROPICAL STORMS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
JTWC	131.4	248.8	356.8	77.6	148.1	222.3	129.8	245.6	351.2	828	513	281
HPAC	139.0	262.4	369.9	83.9	157.8	219.9	137.3	259.0	364.3	790	519	239
TOTL	142.8	265.0	390.8	81.6	145.5	238.1	141.1	261.9	384.6	732	485	296
TPAC	139.0	262.4	395.4	83.9	157.8	247.6	137.3	259.0	388.7	790	519	239
CLIP	133.2	267.5	397.7	81.9	169.7	239.2	131.6	263.7	391.5	559	385	242
RECR	158.0	291.2	419.1	94.8	146.9	226.0	156.1	288.1	413.4	681	440	273
OTCM	137.7	272.7	431.5	87.5	150.4	206.6	135.9	269.5	426.4	396	244	121
CY70	157.3	293.6	440.8	103.6	178.1	246.0	155.2	289.5	434.2	321	215	126
STRA	160.8	308.4	442.7	103.0	205.2	294.6	158.8	303.4	433.8	462	316	199
XTRP	143.8	294.0	449.6	93.9	178.4	266.5	141.9	290.0	442.0	808	537	331
CY50	155.0	292.3	450.4	103.8	175.2	269.8	152.9	288.3	442.5	515	337	196
CLIM	174.0	318.1	455.3	103.0	198.1	291.3	171.9	313.4	446.7	807	531	246
COSM	146.9	304.4	561.9	86.6	170.6	285.6	145.2	300.5	553.5	189	119	62

on typhoons (Table 11) and super typhoons (Table 12) over its tropical storm forecasts. Statistics were computed on a data base that contained only forecasts that were made for a tropical cyclone of at least typhoon intensity. OTCM's mean FTE improved by 20 n mi, while all other techniques showed only a 1-5 n mi improvement.

Note the lower mean errors for super typhoons as compared with typhoons or tropical storms. This is because intense storms are better defined and less erratic in their movement and thus, "easier" to predict. The exception to this is COSM, which performed well on typhoons but showed no improvement on super typhoons. COSM uses the steering flow to make its forecasts. Since super typhoons achieve such strength and size that they modify the steering current, COSM's poor performance in comparison to the other aids is to be expected.

For the computation made in Section 5.4, Table 13 shows the number of times OTCM or HPAC was the best technique for a given storm's intensity and track characteristics. As expected, HPAC is better than OTCM for tropical storms and straight moving storms, while OTCM performs best on recurving typhoons. Even though OTCM's mean FTE is much lower than HPAC's for storms of at least typhoon intensity (Tables 11 and 12), HPAC's FTE was lower more often.

6.2 Diurnal and Seasonal Variations.

Using the homogeneous data base for JTWC, OTCM, HPAC, and RECR mentioned in Section 5.4, the data were screened to show variations in forecast accuracy due to hour and month differences.

To understand the diurnal variation of the forecast accuracy variation, one fact should be kept in mind; JTWC and objective aids make their respective forecasts at different times during the six-hour warning cycle. Intuitively, the HPAC and RECR should have no diurnal variation since they depend heavily on climatology and make no distinction between day or night.

Table 11. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr FTE for the typhoon category during the 1978-85 period. (Units: n mi)

TYPHOONS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
COSM	118.3	232.1	364.3	77.5	145.4	221.9	116.7	229.1	358.7	648	537	419
HPAC	122.0	241.6	365.6	78.7	152.6	233.1	120.4	238.3	359.6	2504	2088	1369
OTCM	124.9	238.3	369.4	78.8	142.4	225.5	123.3	235.3	363.6	1534	1246	866
JTWC	118.4	243.1	370.7	76.7	153.5	241.9	116.9	239.9	364.2	2589	2082	1587
CLIP	113.6	243.7	371.9	73.1	147.6	229.6	112.1	240.6	366.0	2042	1733	1388
TPAC	122.0	241.6	383.9	78.7	152.6	239.7	120.4	238.3	377.5	2504	2088	1369
TOTL	123.3	253.1	385.4	81.5	160.7	240.9	121.6	249.7	378.9	2398	2037	1650
RECR	128.2	261.1	408.3	79.7	151.2	235.1	126.6	257.9	402.1	2328	1972	1590
STRA	134.6	287.2	424.9	97.5	207.5	303.3	132.7	282.1	415.6	1629	1426	1180
CLIM	161.9	302.4	438.6	97.6	178.9	266.7	160.0	298.3	431.2	2544	2130	1404
XTRP	126.5	278.8	445.5	84.9	181.2	280.5	124.9	274.7	437.4	2535	2123	1720
CY70	143.2	295.8	450.8	88.8	171.5	268.3	141.5	292.0	443.1	977	807	612
CY50	138.1	312.6	508.1	96.9	212.5	364.6	136.2	307.4	495.8	1782	1491	1157

Table 12. The mean, standard deviation, median, and sample size of the 24-, 48-, and 72-hr FTE for the super-typhoon category during the 1978-85 period. (Units: n mi)

SUPER-TYPHOONS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	114.3	207.3	300.7	66.5	145.2	178.1	112.8	204.4	296.7	339	293	240
TPAC	113.9	223.9	317.1	80.8	151.6	210.1	112.3	220.7	311.9	558	486	353
HPAC	113.9	223.9	325.6	80.8	151.6	218.8	112.3	220.7	320.1	558	486	353
RECR	107.4	216.1	326.5	74.3	137.0	200.9	105.9	213.3	321.6	555	494	432
JTWC	110.1	220.9	335.4	75.7	155.8	222.6	108.5	217.7	329.8	582	502	432
CLIP	112.1	228.2	340.4	75.8	140.7	217.4	110.6	225.2	334.9	466	408	352
CLIM	139.6	261.2	351.9	92.2	166.3	212.7	137.7	257.6	346.7	566	493	360
COSM	108.1	217.7	363.8	68.0	132.8	169.9	106.7	215.0	359.9	102	90	81
TOTL	114.8	241.9	376.1	74.4	147.1	233.4	113.3	238.8	370.0	558	495	431
STRA	130.1	294.8	426.6	85.4	220.4	294.3	128.4	289.3	417.9	446	408	352
XTRP	124.6	272.7	431.7	95.4	191.7	278.5	122.7	268.3	423.7	573	503	439
CY50	129.6	273.3	440.2	92.3	153.8	230.4	127.8	270.0	434.3	416	358	300
CY70	159.9	303.5	461.4	140.4	211.4	288.2	157.1	298.4	452.9	204	175	147

TABLE 13. FREQUENCY OF OPTIMUM TECHNIQUE SELECTION BETWEEN OTCM AND HPAC BASED ON THE TRACK CHARACTERISTICS AND INTENSITY DATA STRATIFICATION.

The tracks are classified as Straight Moving, Recurving, and Odd Moving. The intensities are classified as Tropical Storm (TS), Typhoon (TY), and Super-Typhoon (ST).

OTCM/HPAC	Straight	Recurver	Odd	Total
Tropical Storm	17/34	8/2	12/16	37/52
Typhoon	96/130	134/75	110/121	340/365
Super Typhoon	18/15	52/75	42/17	112/107
All Storms	131/179	194/191	164/154	489/524

Figure 7, however, shows that the hour at which the forecast is made has an effect on the accuracy of the forecast. This variation actually does not reflect the performance of the method but the accuracy of the storm position fixes. The fixes of 00Z and 06Z are usually the best since they are made during daylight hours. Storm fixes made for 18Z are better than 12Z fixes, since the first daylight fix is available at 22Z (0800L). The forecaster car use this fix to adjust the error prone infrared satellite fixes made at night. The HPAC and RECR variation in Figure 7 reflect this reasoning. Hence, a bad or erroneous fix can influence the forecast accuracy up to 72 hours.

For a number of reasons, 12Z is the best hour for JTWC. The forecasts made at 06Z by the objective aids are good because daytime fixes are used, which improves JTWC's 12Z forecast. The current synoptic analysis fields (00Z) used by the aids are only six hours old vice 12. Also, since 12Z is just after sunset, JTWC forecasters have the entire day to track a storm and thus, have a good idea of its direction and speed. OTCM's 72-hr FTE varies little from hour to hour and thus doesn't appear to be affected by fix accuracy.

Figure 8 shows the variation in mean FTE from month to month. HPAC results show that storms occurring in the most active month of the year (September) are the easiest to forecast. This is because the steering mechanism (the subtropical high)

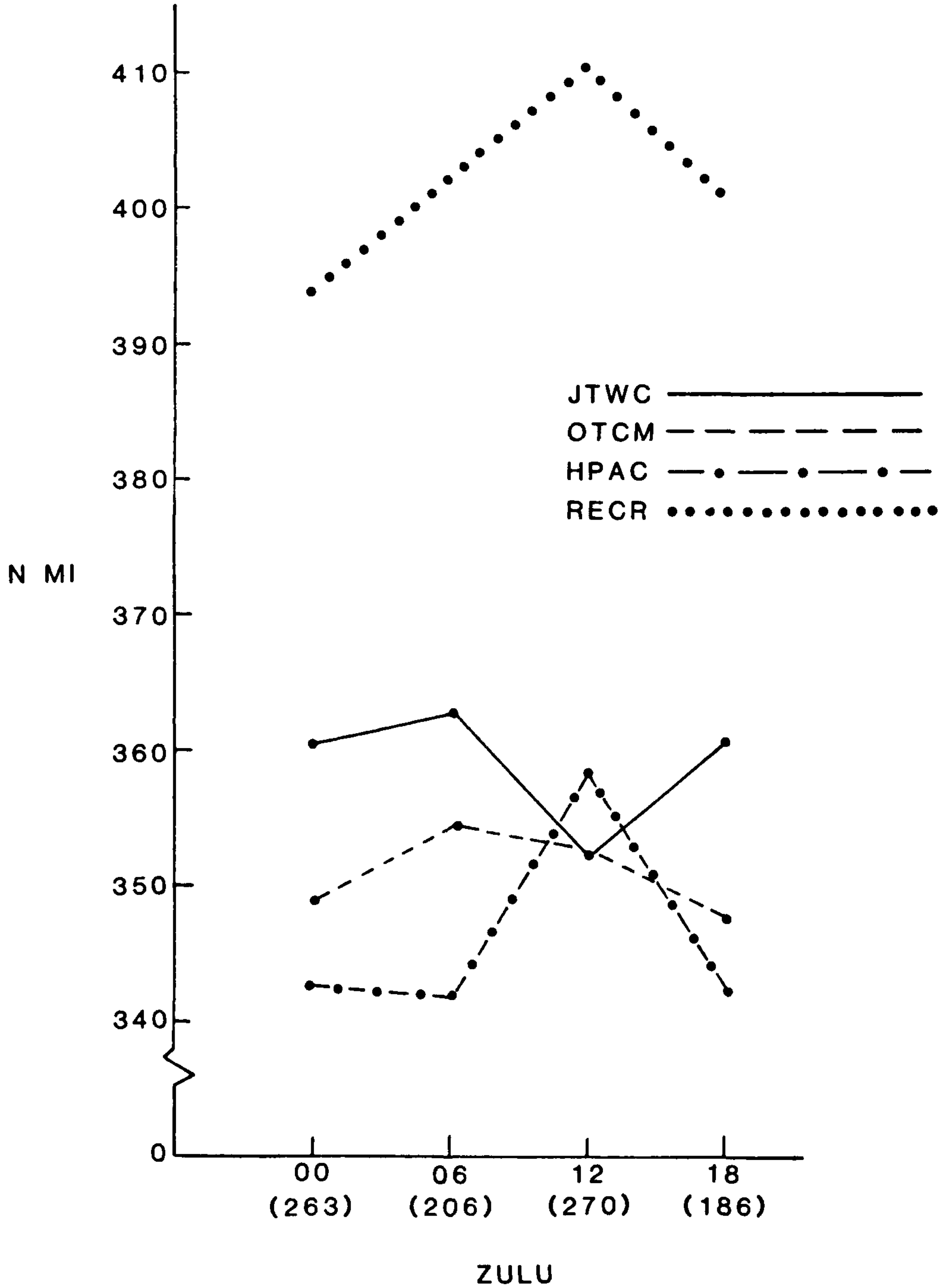


Figure 7. Diurnal variation of the 72 hr FTE among JTWC, OTCM, HPAC and RECR, 1979-85. Sample sizes in parentheses.

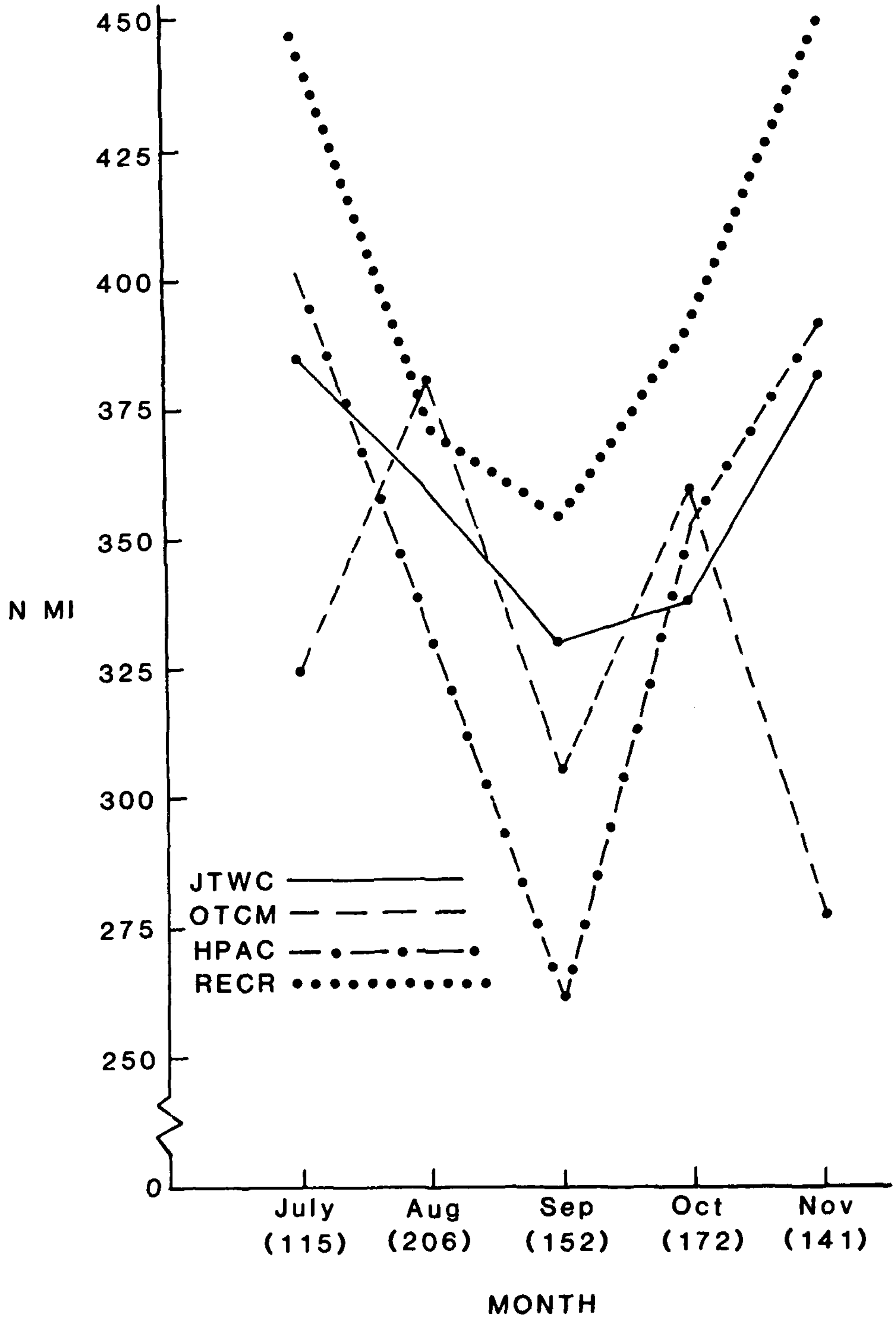


Figure 8. Seasonal variation of the 72 hr FTE among JTWC, OTCM, HPAC and RECR, 1979-85. Sample sizes in parentheses.

is strongest during this month. The accuracy of OTCM, however, does not appear to depend on the month. Figure 8 also shows that, in active months, JTWC forecasters should weigh HPAC and OTCM forecasts more heavily than they have in the past. The F Test shows these two objective aids to be significantly better than JTWC in September (F=3.7605, Fc=3.8724).

6.3 New Objective Aids in 1985

As previously stated, some of the objective aids currently available to JTWC were not discussed because of their small sample size. Their 1985 performance along with JTWC is presented in Table 14. (Year by year tables for all techniques and error types are found in the appendix). Since these results only cover a one year period, the NTCM and CSUM overall performance cannot be truly determined. The two techniques, however, have the capability of being the best forecast aids.

7. SUMMARY

This study was performed to supply the Joint Typhoon Warning Center (JTWC) with a review of the performance characteristics of objective forecast aids currently available to the center.

HPAC had the lowest mean 72-hr FTE for the eight year period 1978-1985. It was not significantly better than OTCM, JTWC, or the other two climatology/persistence models in providing the best track forecast or directional guidance, however. It appears to have a slight bias to the left of the storm path, but the sensitivity test shows that the 1:1 ratio of climatology (CLIM) and persistence (XTRP) produces the lowest mean FTE in comparison with any other ratio combination. In terms of the speed forecast or the ATE, OTCM is the best aid. But, like all other techniques, OTCM shows a tendency to under-forecast storm speed (slow bias).

The analog models STRA and RECR are the top aids on straight and recurving storms, respectively. For these two types of storms, HPAC and OTCM showed reverse behavior; HPAC is better at straight storm forecasting, while OTCM handles recurvers better.

Table 14. The mean, standard deviation, median, and sample size of the 24-, 48, and 72-hr FTE for the JTWC official and objective aid forecasts of 1985 only. (Units: n mi)

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CSUM	91.5	189.6	242.7	60.0	122.2	124.0	90.0	186.4	239.5	79	61	44
HPAC	120.4	233.8	345.4	71.3	134.8	195.4	118.7	230.2	339.2	482	377	272
NTCM	121.2	230.6	355.0	74.7	136.6	197.2	119.3	227.0	348.7	384	305	224
CLIP	121.7	251.9	365.5	75.3	153.0	211.7	119.8	247.6	358.5	348	278	201
JTWC	117.2	230.8	367.2	72.6	153.3	254.4	115.4	226.6	357.7	477	356	241
TPAC	120.4	233.8	369.2	71.3	134.8	200.7	118.7	230.2	362.7	482	377	272
TOTL	121.6	250.8	373.3	77.7	144.6	207.0	119.7	246.9	366.5	468	369	267
COSM	123.9	239.0	382.7	80.6	148.1	239.3	121.9	234.8	374.3	466	363	267
OTCM	115.9	234.1	398.1	67.5	132.4	231.9	114.3	230.6	390.2	474	365	225
XTRP	128.0	268.8	405.8	85.2	171.9	236.8	125.9	263.8	397.4	482	377	274
RECR	133.4	267.1	412.0	77.4	147.3	260.1	131.5	263.1	402.5	444	339	250
CLIM	159.8	299.9	423.2	84.2	152.3	229.0	157.8	295.7	415.3	485	379	274
CY85	170.1	320.7	459.6	105.4	174.5	221.6	167.5	315.5	452.3	242	182	121
CY70	174.0	337.6	489.5	90.1	165.0	264.9	171.9	332.8	479.0	242	182	122
CY50	239.3	465.0	689.1	123.6	256.2	422.5	236.1	455.9	668.8	242	182	122
CY30	358.3	644.6	897.7	194.8	377.0	613.0	352.2	627.6	860.4	242	182	122

JTWC appears to forecast the erratic behavior of tropical storms better than the objective aids and predicts the speed of movement rather well. Because of the initialization method used in OTCM, this model is not dependable for forecasting storms with tropical depression or tropical storm intensity.

It was shown that the accuracy of the storm fix does affect the models forecast accuracy (approximately 20 n mi difference at 72-hr forecast range). In addition, JTWC should follow the guidance of HPAC and OTCM more closely in the active months than it has in the past.

The large number of objective aids (26) currently available to JTWC is adding confusion rather than assistance to the job of forecasting. Tsui (1984) noted that "the key to improve tropical cyclone forecasts may be hinged on the improvement of the utilization of the aids, not necessarily on the improvement of the objective aids." This study has shown that if only OTCM and HPAC were considered, the forecasts could be improved by 27% if the best forecast was always chosen. To obtain this improvement, the JTWC forecaster would only need to choose between two techniques.

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APPENDIX A

ANNUAL FORECASTING ERROR STATISTICS

This appendix includes the listings of annual forecasting error statistics of all objective aids during 1978-85. The computational methodology of each objective aid and the detailed definition of each error measure are given in Sections 2 and 3 of the text.

Objective Aids

BPAC: Blended Persistence and Climatology

CLIM: Climatology

CLIP: Climatology and Persistence Model

COSM: CYCLOPS Objective Steering Model Output Statistics

CSUM: Colorado State University NHC-73 program

CYxx: CYCLOPS steering program. xx stands for the level of steering: 85 for 850mb, 70 for 700mb, etc.

HPAC: Half Persistence and Climatology

JTWC: Official forecasts

NTCM: Nested Tropical Cyclone Model

OTCM: One-way Tropical Cyclone Model

RECR: Recurver TYAN analog program

STRA: Straight Moving TYAN analog program

TOTL: TYAN analog program

TPAC: Quater Persistence and Climatology

XTRP: Persistence or Extrapolation

Error Measures

FTE: The Forecast Error is the shortest distance between the forecast and verifying positions. Units: n mi.

XTE: The Cross-Track Error is one of the two components of the FTE in the natural coordinate system. XTE is perpendicular to the verified track. Positive values indicate that the forecast positions are to the right of the verified track. Units: n mi.

ATE: The Along-Track Error is one of the two components of the FTE in the natural coordinate system. ATE is parallel to the verified track. Positive values indicate that the forecast positions are ahead of the verified positions. Units: n mi.

TKE: The Track Error is the shortest distance between the forecast position and verified track. Positive values indicate that the forecast positions are to the right of the verified track. Units: n mi.

SPE: The Speed Error is the speed difference between the forecast and verified storm movements. Positive values indicate that the forecast positions are ahead of the verified positions. Units: kt.

TME: The Timing Error is the time difference between the verified hour and the forecast hour projected by the TKE. Positive values indicate that the forecast positions are ahead of the verified positions. Units: hour.

STDEV: Standard Deviation.

1978 FTE STATISTICS

TECH	MEAN			STDEV			MEDIAN			COUNT		
	24	48	72	24	48	72	24	48	72	24	48	72
CLIP	119.8	236.4	326.8	71.1	158.3	223.3	118.0	231.9	319.2	368	294	227
TOTL	136.4	254.9	336.2	81.2	166.3	238.8	134.5	250.0	327.9	503	391	305
RECR	142.8	272.0	363.6	83.9	170.8	240.4	140.8	266.9	355.2	496	390	306
OTCM	186.1	298.2	407.8	114.7	182.5	225.7	183.3	292.6	399.9	160	113	40
JTWC	125.5	274.1	410.6	75.6	172.6	256.1	123.6	269.0	401.2	556	420	295
STRA	147.9	307.9	424.1	89.9	209.0	279.7	145.8	301.1	413.0	455	373	291
CY50	144.6	290.8	434.7	84.0	169.2	250.0	142.6	285.8	425.5	363	280	206
CY70	139.8	295.2	450.4	80.5	166.8	230.7	137.8	290.3	442.4	428	328	242
XTRP	141.9	293.7	469.8	119.2	180.5	283.8	139.1	288.1	458.6	543	418	327
CLIM	183.0	326.4	-999.9	168.8	207.8	-999.9	178.8	319.6	-999.9	517	386	0
HPAC	135.9	261.0	-999.9	88.3	168.9	-999.9	133.8	256.1	-999.9	516	385	0
TPAC	135.9	261.0	-999.9	88.3	168.9	-999.9	133.8	256.1	-999.9	516	385	0

1979 FTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
TPAC	134.3	227.9	294.3	104.1	150.2	198.0	133.0	226.0	291.0	569	467	213
HPAC	134.3	227.9	315.4	104.1	150.2	220.8	133.0	226.0	311.0	569	467	213
JTWC	125.0	226.9	316.0	85.2	153.8	210.0	124.0	225.0	312.0	589	469	366
CLIP	123.7	225.2	324.1	79.1	130.5	179.5	123.0	223.0	321.0	431	371	303
CLIM	153.6	259.6	332.8	101.2	166.9	192.9	152.0	257.0	329.0	576	472	217
TOTL	135.5	245.1	342.4	87.3	149.7	201.0	134.0	243.0	339.0	550	464	383
RECR	139.9	248.7	347.9	94.3	162.9	213.5	139.0	246.0	344.0	523	438	358
OTCM	127.3	249.5	364.7	93.5	203.6	277.4	126.0	246.0	359.0	123	101	83
XTRP	150.0	285.3	438.1	155.7	187.4	274.9	148.0	282.0	432.0	582	482	398
STRA	152.8	307.5	455.4	96.0	210.8	291.7	152.0	304.0	449.0	532	461	379
CY70	157.1	303.5	466.1	126.2	201.1	279.7	155.0	300.0	460.0	444	357	264
CY50	151.1	290.2	467.7	105.3	160.7	228.7	150.0	288.0	463.0	432	356	259

1980 FTE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
OTCM	137.3	257.2	346.0	75.6	162.5	208.6	136.0	255.0	342.0	155	126	82
HPAC	130.1	249.1	371.5	78.9	152.1	222.5	129.0	247.0	367.0	475	380	294
TOTL	126.5	244.4	380.4	75.3	142.9	212.5	126.0	242.0	377.0	415	344	267
CLIP	121.5	250.7	383.1	74.3	154.9	231.2	121.0	248.0	379.0	364	301	229
TPAC	130.1	249.1	385.0	78.9	152.1	216.4	129.0	247.0	381.0	475	380	294
RECR	135.5	258.2	388.8	79.8	135.6	192.6	135.0	256.0	386.0	415	344	267
JTWC	126.7	243.8	390.8	74.1	131.2	229.5	126.0	242.0	386.0	491	369	267
CY70	133.7	266.4	419.9	89.6	165.8	285.9	133.0	264.0	414.0	430	348	262
CY50	134.4	255.8	420.4	86.2	158.0	278.2	133.0	253.0	414.0	435	355	269
CLIM	158.4	294.8	442.2	91.4	164.1	236.6	157.0	292.0	438.0	486	389	301
STRA	135.7	296.8	453.3	86.3	209.8	325.7	135.0	293.0	445.0	348	298	241
XTRP	142.3	296.7	471.1	95.2	200.1	303.8	141.0	293.0	464.0	489	395	305

1981 FTE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
OTCM	120.3	219.1	314.5	65.6	139.1	219.9	119.0	217.0	310.0	157	124	79
JTWC	123.9	220.5	334.3	84.4	143.1	244.5	123.0	218.0	329.0	466	348	246
HPAC	123.4	248.9	375.3	86.0	158.4	247.0	122.0	246.0	370.0	444	348	271
BPAC	125.6	255.6	396.3	90.6	150.4	237.4	124.0	253.0	392.0	439	352	270
TPAC	123.4	248.9	398.8	86.0	158.4	241.6	122.0	246.0	394.0	444	348	271
STRA	139.7	288.7	412.4	117.8	238.4	357.9	138.0	284.0	403.0	367	306	235
CLIP	119.6	259.2	417.9	87.8	161.5	261.3	119.0	257.0	412.0	369	292	222
RECR	129.3	262.0	423.4	85.4	148.1	234.8	128.0	260.0	419.0	406	326	252
TOTL	127.2	262.1	423.4	84.9	160.0	252.0	126.0	260.0	418.0	414	335	259
NTCM	151.2	276.4	442.8	85.8	167.5	288.9	150.0	274.0	436.0	120	100	76
CLIM	158.0	305.6	450.5	93.6	159.7	253.4	157.0	303.0	445.0	464	371	287
XTRP	131.9	289.7	458.3	94.5	186.4	302.4	131.0	287.0	451.0	450	350	271
CY50	133.3	324.0	571.2	102.8	246.6	479.6	132.0	319.0	555.0	412	320	238

1982 FTE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
HPAC	110.4	216.4	340.6	72.8	142.0	230.1	109.0	214.0	336.0	628	537	450
JTWC	113.3	237.7	341.7	73.1	157.6	225.5	112.0	235.0	337.0	660	532	425
OTCM	122.0	232.9	347.0	73.6	133.6	219.9	121.0	231.0	343.0	474	402	327
NTCM	142.8	238.0	352.2	85.5	140.3	181.2	142.0	236.0	349.0	180	152	122
TPAC	110.4	216.4	356.8	72.8	142.0	254.2	109.0	214.0	352.0	628	537	450
TOTL	112.3	230.3	372.8	72.1	144.8	246.2	111.0	228.0	368.0	608	521	438
CLIP	107.1	238.7	374.5	66.0	142.0	228.7	106.0	237.0	370.0	546	472	394
RECR	115.9	237.3	387.3	77.5	144.5	243.6	115.0	235.0	382.0	584	502	420
BPAC	122.6	247.9	388.2	79.6	169.0	285.3	122.0	245.0	382.0	608	524	439
STRA	121.2	257.7	390.0	85.6	185.3	271.3	120.0	255.0	384.0	585	511	432
CLIM	150.3	272.2	410.2	98.5	181.9	295.7	149.0	269.0	404.0	643	551	464
XTRP	115.2	261.8	428.5	71.1	159.4	256.2	114.0	259.0	423.0	630	539	453
CY50	111.4	277.2	463.6	69.1	184.3	311.9	111.0	274.0	456.0	575	494	406

1983 FTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
HPAC	114.4	216.0	295.9	83.1	137.1	193.8	113.0	214.0	293.0	313	232	170
TPAC	114.4	216.0	308.2	83.1	137.1	211.7	113.0	214.0	304.0	313	232	170
NTCM	158.5	244.9	334.9	107.2	159.6	206.4	157.0	242.0	331.0	264	195	149
CLIP	110.3	236.5	350.5	83.3	165.2	262.6	109.0	234.0	345.0	267	194	146
RECR	125.3	236.1	354.3	96.3	128.9	199.6	124.0	234.0	351.0	287	215	160
CLIM	152.8	270.4	355.9	108.9	174.4	248.9	151.0	268.0	351.0	318	236	173
XTRP	114.2	243.0	357.3	87.5	183.5	240.2	113.0	240.0	353.0	314	233	172
OTCM	103.7	207.2	359.3	67.6	125.0	185.7	103.0	205.0	356.0	265	192	140
BPAC	129.1	244.1	370.1	87.4	162.3	259.4	128.0	242.0	365.0	299	222	160
JTWC	116.7	260.2	407.3	76.1	167.0	249.3	116.0	258.0	402.0	342	253	184
TOTL	125.0	264.6	408.2	90.3	170.9	264.5	124.0	262.0	403.0	305	228	169
STRA	138.8	299.1	442.3	106.7	206.7	285.2	137.0	295.0	436.0	294	220	160
CY50	113.2	316.3	511.3	76.1	179.6	300.9	112.0	313.0	504.0	294	217	158

1984 FTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	129.7	242.0	363.0	78.7	136.2	190.7	127.8	238.4	357.0	474	364	251
JTWC	116.9	232.6	363.2	77.1	134.8	221.0	115.0	229.0	355.7	492	378	286
COSM	124.6	245.9	389.0	81.2	154.1	224.7	122.6	241.7	381.5	486	387	295
CLIP	120.4	262.4	414.1	74.4	147.4	228.7	118.7	258.4	406.2	419	342	266
NTCM	121.2	257.3	428.9	79.3	170.2	251.8	119.3	252.4	420.0	435	353	274
HPAC	133.5	284.6	436.2	79.2	169.4	246.8	131.6	279.6	427.3	500	395	299
TPAC	133.5	284.6	459.5	79.2	169.4	260.0	131.6	279.6	449.9	500	395	299
TOTL	129.9	288.3	470.0	81.9	172.5	266.9	127.9	283.2	459.9	489	389	296
RECR	129.8	284.5	477.1	76.4	146.2	211.1	127.9	280.5	470.1	472	376	289
XTRP	125.3	239.7	480.5	83.8	189.8	297.9	123.3	283.7	468.4	503	397	300
CLIM	183.4	362.8	514.3	101.4	209.8	288.7	180.9	356.0	503.1	503	398	302

1985 FTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CSUM	91.5	189.6	242.7	60.0	122.2	124.0	90.0	186.4	239.5	79	61	44
HPAC	120.4	233.8	345.4	71.3	134.8	195.4	118.7	230.2	339.2	482	377	272
NTCM	121.2	230.6	355.0	74.7	136.6	197.2	119.3	227.0	348.7	384	305	224
CLIP	121.7	251.9	365.5	75.3	153.0	211.7	119.8	247.6	358.5	348	278	201
JTWC	117.2	230.8	367.2	72.6	153.3	254.4	115.4	226.6	357.7	477	356	241
TPAC	120.4	233.8	369.2	71.3	134.8	200.7	118.7	230.2	362.7	482	377	272
TOTL	121.6	250.8	373.3	77.7	144.6	207.0	119.7	246.9	366.5	468	369	267
COSM	123.9	239.0	382.7	80.6	148.1	239.3	121.9	234.8	374.3	466	363	267
OTCM	115.9	234.1	398.1	67.5	132.4	231.9	114.3	230.6	390.2	474	365	225
XTRP	128.0	268.8	405.8	85.2	171.9	236.8	125.9	263.8	397.4	482	377	274
RECR	133.4	267.1	412.0	77.4	147.3	260.1	131.5	263.1	402.5	444	339	250
CLIM	159.8	299.9	423.2	84.2	152.3	229.0	157.8	295.7	415.3	485	379	274
CY85	170.1	320.7	459.6	105.4	174.5	221.6	167.5	315.5	452.3	242	182	121
CY70	174.0	337.6	489.5	90.1	165.0	264.9	171.9	332.8	479.0	242	182	122
CY50	239.3	465.0	689.1	123.6	256.2	422.5	236.1	455.9	668.8	242	182	122
CY30	358.3	644.6	897.7	194.8	377.0	613.0	352.2	627.6	860.4	242	182	122

1978 XTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CLIP	69.4	137.7	191.2	85.7	182.1	242.5	-9.6	-17.9	1.4	368	294	227
TOTL	82.9	140.7	192.1	102.8	183.5	257.7	-22.4	-34.0	-49.1	503	391	305
RECR	83.7	149.2	206.8	105.7	198.6	279.9	-4.9	0.3	9.0	496	390	306
JTWC	70.7	150.7	218.2	89.6	189.4	275.7	-20.9	-40.9	-71.9	556	420	295
OTCM	101.9	147.7	240.6	107.8	173.0	290.8	-72.5	-85.2	-121.7	160	113	40
CY70	78.4	150.2	244.3	95.2	193.2	301.5	-30.4	-33.1	9.7	428	328	242
CY50	86.2	159.3	245.2	103.5	207.3	319.2	-36.4	-37.4	-11.5	363	280	206
XTRP	79.2	156.3	252.1	123.2	198.5	315.3	-37.9	-54.1	-101.1	543	418	327
STRA	95.6	190.3	259.1	114.9	233.5	306.8	-42.7	-102.3	-172.2	455	373	291
CLIM	106.9	188.2	-999.9	179.4	240.9	-999.9	-14.9	-23.0	-999.9	517	386	0
HPAC	73.2	137.0	-999.9	93.2	174.2	-999.9	-22.6	-37.4	-999.9	516	385	0
TPAC	73.2	137.0	-999.9	93.2	174.2	-999.9	-22.6	-37.4	-999.9	516	385	0

1979 XTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
HPAC	76.1	127.2	158.2	93.4	162.6	202.6	-22.2	-29.1	-4.8	568	467	213
TPAC	76.1	127.2	159.0	93.4	162.6	197.9	-22.2	-29.1	20.8	568	467	213
JTWC	76.3	137.8	181.8	96.3	177.0	239.4	-30.6	-40.0	-49.8	589	469	366
CLIP	72.7	134.3	189.2	92.5	170.1	235.5	-17.9	-8.3	8.9	431	371	303
RECR	85.8	150.5	189.6	111.4	200.7	249.7	-25.7	-22.9	-15.3	523	438	358
OTCM	57.8	121.6	191.8	72.4	150.1	236.4	-12.2	-40.6	-59.2	123	101	83
CLIM	90.0	152.1	197.4	113.6	187.8	234.8	-6.8	18.5	46.3	576	472	217
TOTL	86.0	150.1	198.2	105.7	184.1	238.2	-35.5	-57.8	-68.5	550	464	383
CY70	97.1	152.9	230.4	128.3	195.3	299.0	-49.3	-51.7	-15.6	444	357	264
XTRP	85.8	165.8	234.0	107.2	206.0	300.9	-38.4	-76.0	-83.6	581	482	398
CY50	97.2	172.1	254.0	117.0	211.4	319.5	-52.4	-62.5	-54.3	432	356	259
STRA	101.4	191.8	267.6	116.0	212.8	281.4	-53.2	-122.5	-191.4	532	461	379

1980 XTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
HPAC	71.2	131.7	188.3	89.3	161.9	238.8	-14.8	-4.3	7.0	475	380	294
TOTL	72.1	132.0	188.6	89.2	158.8	231.2	-20.1	-43.4	-35.0	415	344	267
CY70	78.0	125.1	202.4	96.7	159.0	273.1	-26.3	-18.0	26.5	430	348	262
TPAC	71.2	131.7	212.9	89.3	161.9	257.8	-14.8	-4.3	45.8	475	380	294
CLIP	69.1	148.5	218.8	90.2	204.2	295.9	-13.2	-13.3	-3.2	364	301	229
CY50	78.7	130.6	227.0	95.5	167.7	296.9	-32.9	-27.6	-20.8	435	355	269
JTWC	75.5	146.9	229.6	96.8	180.0	280.9	-5.8	12.2	67.6	491	369	267
RECR	75.6	154.1	233.1	92.7	184.8	270.4	15.0	35.6	63.4	415	344	267
STRA	76.5	149.2	233.3	86.9	168.9	288.2	-43.9	-100.8	-131.2	348	298	241
OTCM	72.3	152.2	237.0	87.4	192.4	300.8	-16.6	-54.8	-104.5	155	126	82
XTRP	82.5	164.1	241.5	100.4	197.7	289.1	-32.0	-66.3	-89.9	489	395	305
CLIM	87.7	167.4	260.5	112.8	204.9	299.5	1.4	43.0	84.0	486	389	301

1981 XTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	65.0	125.9	201.4	81.5	161.9	248.1	6.8	-34.4	-115.3	157	124	79
STRA	87.6	166.2	217.9	110.5	214.6	283.8	-49.5	-111.4	-113.2	367	306	235
HPAC	71.8	137.4	218.8	92.0	177.7	267.1	-12.6	-14.2	16.6	444	348	271
JTWC	77.1	130.9	219.0	102.4	178.8	290.6	-10.5	-10.9	-14.0	466	348	246
XTRP	78.5	162.0	231.0	98.8	194.2	291.0	-30.7	-75.5	-97.0	450	350	271
CLIP	63.2	134.9	237.6	82.4	178.5	286.2	-2.9	8.4	57.2	369	292	222
NTCM	86.3	151.8	245.3	103.9	182.6	306.3	3.3	25.1	31.4	120	100	76
TOTL	79.5	154.8	252.4	100.6	197.0	307.4	-14.1	-36.8	-.2	414	335	259
TPAC	71.8	137.4	253.5	92.0	177.7	298.4	-12.6	-14.2	68.3	444	348	271
BPAC	77.9	158.5	262.1	102.6	197.0	309.3	-5.8	11.8	67.9	439	352	270
RECR	76.2	167.7	294.1	91.8	195.3	322.3	25.3	59.0	139.6	406	326	252
CLIM	97.9	199.4	304.9	122.6	236.3	343.7	4.3	42.1	115.1	464	371	287
CY50	77.1	168.0	318.6	105.0	256.7	475.8	-11.9	20.2	44.5	412	320	238

1982 XTE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
HPAC	62.4	121.2	200.5	79.3	154.6	266.2	-21.9	-45.8	-37.1	628	537	450
JTWC	70.4	141.6	210.9	90.2	182.9	267.3	-14.2	-36.9	-57.3	660	532	425
TPAC	62.4	121.2	214.2	79.3	154.6	289.4	-21.9	-45.8	-17.0	628	537	450
OTCM	62.5	132.6	216.5	77.8	175.1	284.8	12.6	-12.5	-30.4	474	402	327
NTCM	67.4	119.9	217.7	76.4	153.0	269.5	36.3	37.4	35.1	180	152	122
CLIP	63.3	140.5	232.8	80.8	175.9	290.7	-7.0	-9.5	-1.3	546	472	394
TOTL	72.4	143.7	238.0	92.8	173.6	291.9	-18.3	-69.9	-91.8	608	521	438
RECR	68.5	135.6	245.0	90.3	173.6	287.2	10.4	26.0	103.2	584	502	420
STRA	73.8	156.5	250.8	92.4	187.3	312.5	-33.5	-92.8	-110.0	585	511	432
CLIM	86.3	158.1	255.1	112.7	210.9	344.4	-16.9	-19.3	0.4	643	551	464
BPAC	79.9	159.9	257.3	103.6	201.0	345.2	-12.5	-17.6	4.1	608	524	439
CY50	63.8	157.9	261.9	84.6	207.4	345.7	-13.5	17.1	31.4	575	494	406
XTRP	68.2	155.8	266.4	85.2	189.9	332.6	-27.9	-76.8	-89.7	630	539	453

1983 XTE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
HPAC	65.8	128.9	195.1	81.5	153.5	223.1	-22.1	-53.7	-106.2	313	232	170
TPAC	65.8	128.9	214.4	81.5	153.5	256.3	-22.1	-53.7	-107.6	313	232	170
XTRP	69.6	143.2	214.6	91.9	181.1	257.1	-19.4	-52.0	-111.2	314	233	172
NTCM	69.0	133.3	224.7	92.3	169.0	278.9	-2.3	-9.1	-44.1	264	195	149
CLIP	66.0	149.6	235.3	88.6	186.8	283.2	-12.3	-28.3	-54.8	267	194	146
BPAC	82.5	154.5	238.0	104.5	193.0	286.5	-23.7	-61.0	-121.0	299	222	160
CLIM	87.7	169.8	247.7	111.9	204.3	311.0	-25.8	-60.8	-113.4	318	236	173
OTCM	59.2	145.3	254.4	73.3	171.8	284.9	-6.7	-39.1	-111.5	265	192	140
RECR	71.4	160.2	257.7	88.6	188.3	305.2	8.3	10.8	37.8	287	215	160
JTWC	72.6	164.3	262.5	88.7	207.1	316.9	-14.3	-27.5	-91.9	342	253	184
TOTL	76.7	170.5	288.9	92.8	189.8	318.1	-26.7	-92.9	-186.0	305	228	169
STRA	84.5	184.2	312.6	97.2	181.8	330.3	-41.2	-126.7	-228.3	294	220	160
CY50	64.5	195.2	323.7	85.6	269.2	440.4	-3.8	30.8	104.3	294	217	158

1984 XTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
JTWC	64.3	131.0	215.9	83.8	168.7	270.7	-13.7	-16.1	-31.0	492	378	286
NTCM	52.5	112.4	216.4	68.2	142.5	266.6	-4.1	1.8	34.5	435	353	274
OTCM	74.2	140.3	217.3	89.1	167.6	266.0	-.8	-5.0	13.2	474	364	251
COSM	56.3	119.0	225.4	69.2	137.1	230.4	19.7	49.7	128.4	486	387	295
HPAC	70.1	146.7	229.6	85.0	185.9	277.0	-21.1	-30.1	-22.2	500	395	299
CLIP	64.5	145.1	237.8	81.0	180.7	296.1	-7.7	-.6	-5.4	419	342	266
TPAC	70.1	146.7	250.9	85.0	185.9	315.0	-21.1	-30.1	14.4	500	395	299
XTRP	66.5	144.4	253.0	82.5	180.5	303.9	-28.7	-76.4	-105.7	503	397	300
TOTL	81.2	168.3	263.2	101.6	206.5	326.7	-22.9	-61.9	-60.6	489	389	296
CLIM	100.9	202.6	298.5	126.6	264.5	375.4	-15.4	8.3	46.7	503	398	302
RECR	79.3	176.8	313.1	100.3	210.6	357.1	7.7	28.6	75.3	472	376	289

1985 XTE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CSUM	55.6	114.0	160.2	69.8	155.5	202.4	-24.9	-.5	13.6	79	61	44
NTCM	68.0	128.9	191.7	87.7	163.7	243.3	-5.8	10.0	4.5	384	305	224
HPAC	68.4	137.4	216.3	87.7	176.6	274.8	-12.7	2.3	10.7	482	377	272
COSM	61.3	128.7	225.5	78.7	154.3	259.2	10.6	51.5	103.9	466	363	267
JTWC	68.1	137.8	227.1	85.8	179.3	308.9	-16.8	-14.0	-26.2	477	356	241
CLIP	69.0	148.3	232.7	87.1	184.4	274.3	-3.1	30.7	84.3	348	278	201
TOTL	76.2	156.3	242.3	97.9	194.3	312.3	-9.6	-2.7	-5.0	468	369	267
TPAC	68.4	137.4	244.6	87.7	176.6	307.4	-12.7	2.3	13.9	482	377	272
XTRP	72.9	158.1	253.6	90.9	203.4	313.5	-24.0	-25.5	-9.2	482	377	274
OTCM	65.9	146.8	258.6	81.6	182.3	313.3	-18.2	-13.2	-37.7	474	365	225
RECR	81.1	166.2	264.7	97.6	190.0	300.0	24.1	70.4	118.2	444	339	250
CY85	88.5	183.2	272.2	104.2	211.7	302.9	31.9	90.1	139.1	242	182	121
CLIM	103.7	198.8	293.9	127.8	245.5	369.6	-3.4	19.6	7.6	485	379	274
CY70	101.5	218.4	338.4	95.8	192.7	307.5	74.5	175.5	271.2	242	182	122
CY50	154.4	303.0	473.3	148.6	280.3	469.4	109.9	227.8	356.7	242	182	122
CY30	215.8	381.8	565.5	248.8	437.2	678.7	133.2	221.4	-999.9	242	182	122

1978 ATE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CLIP	83.0	161.1	228.1	97.9	197.3	299.1	-51.9	-102.2	-111.1	368	294	227
TOTL	91.2	178.9	229.3	113.5	232.9	311.3	-39.9	-74.4	-96.8	503	391	305
RECR	99.3	195.5	257.7	122.1	245.5	330.8	-40.5	-70.8	-68.4	496	390	306
STRA	93.6	199.8	270.4	114.6	259.8	360.3	-48.5	-105.3	-132.8	455	373	291
OTCM	129.8	222.1	279.1	145.5	247.9	303.1	-105.6	-170.1	-192.1	160	113	40
JTWC	86.8	194.1	296.1	101.3	229.1	356.6	-55.8	-135.6	-195.5	556	420	295
CY50	98.4	211.9	302.2	113.8	233.4	356.7	-59.5	-133.4	-176.3	363	280	206
CY70	98.5	220.4	326.1	112.6	246.7	356.5	-62.4	-139.4	-219.7	428	328	242
XTRP	99.2	211.4	337.7	118.2	239.2	396.1	-69.3	-153.9	-231.3	543	418	327
CLIM	125.2	225.5	-999.9	161.5	281.9	-999.9	-74.0	-127.4	-999.9	517	386	0
HPAC	99.3	191.7	-999.9	113.9	220.4	-999.9	-68.1	-140.0	-999.9	516	385	0
TPAC	99.3	191.7	-999.9	113.9	220.4	-999.9	-68.1	-140.0	-999.9	516	385	0

1979 ATE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
JTWC	80.8	146.3	213.9	108.7	198.0	283.2	-34.9	-67.9	-88.2	589	469	366
TPAC	90.7	161.1	214.2	114.1	203.3	288.3	-53.9	-87.4	-70.7	568	467	213
CLIP	83.4	150.1	218.2	107.8	191.1	281.7	-36.8	-56.1	-62.7	431	371	303
TOTL	84.6	158.4	231.5	112.7	208.0	302.9	-35.4	-61.4	-95.8	550	464	383
CLIM	105.9	184.6	234.0	136.4	238.2	298.8	-52.3	-63.4	-40.1	576	472	217
HPAC	90.7	161.1	236.5	114.1	203.3	312.8	-53.9	-87.4	-118.5	568	467	213
RECR	89.8	163.4	249.6	122.8	217.6	320.9	-24.8	-33.0	-59.4	523	438	358
OTCM	99.5	190.8	260.6	112.5	232.3	326.7	-86.7	-174.7	-240.7	123	101	83
STRA	91.6	191.8	299.6	122.4	272.4	408.7	-44.5	-99.4	-167.1	532	461	379
XTRP	97.4	195.7	317.4	124.4	242.2	373.6	-56.4	-116.7	-212.4	581	482	398
CY50	96.7	197.4	331.0	128.0	233.3	371.9	-42.0	-100.4	-200.4	432	356	259
CY70	104.0	230.4	358.3	140.0	275.4	402.5	-55.0	-143.8	-246.2	444	357	264

1980 ATE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	101.1	170.2	194.5	103.9	210.3	244.5	-79.8	-105.4	-86.9	155	126	82
JTWC	86.0	165.0	265.7	103.6	197.4	324.7	-40.6	-78.3	-143.2	491	369	267
RECR	98.2	177.1	267.0	108.2	199.5	312.2	-67.3	-104.7	-128.6	415	344	267
CLIP	85.7	171.4	269.0	97.1	189.7	302.7	-53.5	-103.3	-163.3	364	301	229
HPAC	94.8	188.2	277.0	100.9	203.2	304.3	-72.3	-142.2	-216.6	475	380	294
TPAC	94.8	188.2	280.6	100.9	203.2	301.3	-72.3	-142.2	-206.6	475	380	294
TOTL	90.4	180.9	283.6	103.5	197.1	314.5	-54.7	-129.4	-214.0	415	344	267
CY50	92.7	192.8	302.8	118.1	214.3	354.3	-42.5	-135.8	-231.1	435	355	269
CLIM	114.1	211.4	314.4	117.0	222.5	350.5	-87.3	-151.1	-196.7	486	389	301
CY70	92.3	210.5	327.2	118.1	231.5	367.1	-48.6	-150.8	-249.5	430	348	262
STRA	95.3	218.0	330.0	109.2	250.6	382.1	-71.4	-193.9	-302.6	348	298	241
XTRP	99.0	216.3	349.1	123.6	266.4	428.6	-59.4	-137.0	-999.9	489	395	305

1981 ATE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
OTCM	90.3	153.8	198.2	96.0	192.9	260.8	-55.3	-61.8	-94.8	157	124	79
JTWC	79.7	146.1	205.6	105.8	184.9	283.3	-29.2	-59.5	-95.8	466	348	246
RECR	88.8	173.4	247.5	108.1	195.3	294.4	-58.2	-105.2	-151.4	406	326	252
BPAC	82.6	171.8	248.3	109.7	202.2	302.2	-40.1	-94.9	-152.6	439	352	270
TPAC	85.7	179.7	257.2	103.5	196.1	301.4	-60.1	-135.8	-188.0	444	348	271
HPAC	85.7	179.7	263.7	103.5	196.1	305.6	-60.1	-135.8	-204.2	444	348	271
CLIM	104.3	196.1	271.3	117.5	212.1	327.5	-72.3	-130.6	-169.3	464	371	287
STRA	91.6	190.5	285.1	122.4	252.0	416.5	-66.5	-152.4	-216.5	367	306	235
TOTL	81.8	179.8	287.6	106.8	202.3	326.4	-44.0	-123.4	-219.3	414	335	259
CLIP	88.2	194.6	300.4	112.2	205.6	327.6	-53.6	-143.8	-236.2	369	292	222
NTCM	106.9	202.8	300.5	113.0	224.3	377.9	-83.3	-148.4	-223.6	120	100	76
XTRP	88.4	206.6	348.4	117.7	243.7	403.4	-46.4	-138.7	-241.9	450	350	271
CY50	92.1	233.4	391.5	123.8	259.6	472.5	-46.8	-187.7	-355.6	412	320	238

1982 ATE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	92.7	161.6	221.4	104.8	196.0	293.1	-57.5	-60.2	-53.1	474	402	327
JTWC	73.8	162.0	222.6	93.5	200.4	272.4	-36.0	-88.6	-152.7	660	532	425
HPAC	77.1	153.3	232.7	92.8	179.7	275.9	-48.8	-100.8	-158.1	628	537	450
NTCM	109.8	179.9	235.0	112.5	195.8	248.5	-90.6	-118.6	-151.0	180	152	122
TOTL	71.7	149.4	238.3	91.4	185.0	300.5	-26.6	-80.3	-149.3	608	521	438
TPAC	77.1	153.3	239.6	92.8	179.7	295.1	-48.8	-100.8	-158.8	628	537	450
BPAC	76.4	158.9	245.5	101.9	219.0	325.3	-14.7	-47.7	-101.9	608	524	439
STRA	79.7	170.3	246.1	99.8	213.7	309.2	-52.4	-119.8	-170.4	585	511	432
RECR	79.8	168.9	252.5	98.3	202.5	320.2	-40.3	-76.7	-118.3	584	502	420
CLIP	73.8	166.0	253.5	89.0	196.3	295.1	-38.6	-93.4	-157.0	546	472	394
CLIM	104.9	188.4	266.8	128.6	234.4	342.6	-56.5	-95.7	-157.7	643	551	464
XTRP	78.1	176.0	279.5	95.2	209.1	335.8	-38.4	-103.1	-161.4	630	539	453
CY50	77.7	191.5	316.2	88.0	205.0	348.3	-48.3	-165.0	-283.5	575	494	406

1983 ATE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
TPAC	79.2	142.6	175.3	99.6	175.7	234.5	-57.2	-97.8	-109.0	313	232	170
HPAC	79.2	142.6	178.0	99.6	175.7	237.7	-57.2	-97.8	-106.4	313	232	170
CLIM	104.4	174.5	198.6	131.9	222.3	266.3	-72.0	-105.3	-121.1	318	236	173
OTCM	70.0	115.7	201.3	89.5	159.3	261.6	-45.7	-54.9	-78.5	265	192	140
NTCM	125.7	175.9	202.0	131.9	196.6	232.8	-106.5	-140.8	-156.1	264	195	149
RECR	89.2	145.7	212.3	117.9	179.4	262.4	-58.5	-71.4	-34.5	287	215	160
CLIP	73.6	152.3	216.5	95.8	205.5	324.4	-46.5	-81.2	-86.9	267	194	146
TOTL	82.6	163.3	223.9	109.3	207.3	302.1	-54.0	-119.8	-143.4	305	228	169
BPAC	82.5	155.4	231.3	106.8	203.9	328.2	-41.8	-71.7	-76.9	299	222	160
XTRP	75.5	165.9	237.4	101.3	224.5	318.8	-43.5	-94.0	-105.2	314	233	172
STRA	92.6	190.1	237.7	123.9	256.0	299.0	-68.7	-148.5	-202.3	294	220	160
JTWC	75.7	169.3	258.5	100.5	214.0	337.9	-38.4	-87.6	-105.8	342	253	184
CY50	80.0	196.1	307.1	95.4	187.2	295.8	-48.9	-156.2	-233.5	294	217	158

1984 ATE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
JTWC	84.0	162.5	238.4	100.2	182.7	283.8	-51.1	-106.6	-175.1	492	378	286
OTCM	93.4	169.1	246.0	107.4	209.5	297.4	-61.8	-78.0	-103.3	474	364	251
COSM	100.3	189.7	274.4	104.1	205.2	306.1	-80.1	-149.3	-203.5	486	387	295
CLIP	89.1	187.5	284.2	97.6	198.1	301.7	-64.7	-142.5	-225.3	419	342	266
RECR	87.1	188.1	299.2	100.7	211.4	323.0	-50.7	-115.6	-190.4	472	376	289
TOTL	86.5	198.4	325.4	101.5	219.1	342.6	-52.4	-146.2	-275.1	489	389	296
NTCM	99.5	208.4	326.5	100.6	214.2	325.8	-80.9	-176.8	-276.9	435	353	274
HPAC	101.2	212.8	326.7	101.8	211.9	314.2	-80.6	-179.0	-289.5	500	395	299
TPAC	101.2	212.8	329.8	101.8	211.9	327.3	-80.6	-179.0	-283.2	500	395	299
CLIM	135.4	255.7	343.4	139.2	273.2	366.5	-94.9	-185.6	-281.0	503	398	302
XTRP	92.6	216.6	360.0	104.1	233.5	368.7	-68.4	-175.1	-309.4	503	397	300

1985 ATE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
CSUM	61.2	127.5	146.5	80.2	152.2	169.9	-13.4	-63.1	-67.5	79	61	44
HPAC	83.8	158.3	221.6	93.3	176.8	245.8	-57.6	-106.3	-153.4	482	377	272
TPAC	83.8	158.3	222.7	93.3	176.8	246.1	-57.6	-106.3	-151.9	482	377	272
TOTL	79.2	160.0	223.6	99.9	202.8	267.6	-36.8	-76.2	-123.8	468	369	267
JTWC	80.2	153.3	229.6	99.4	200.1	306.1	-41.6	-73.3	-116.4	477	356	241
CLIP	85.8	173.7	236.7	98.2	199.4	276.2	-59.2	-114.3	-142.7	348	278	201
CLIM	100.2	184.1	244.7	113.1	207.7	276.7	-61.7	-100.1	-142.7	485	379	274
OTCM	79.6	150.3	251.5	94.7	195.9	330.6	-47.6	-32.2	-84.0	474	365	225
NTCM	84.7	163.7	251.9	98.8	196.6	310.8	-55.0	-84.0	-107.9	384	305	224
RECR	91.0	175.6	258.6	107.4	211.7	337.6	-47.2	-84.9	-142.6	444	339	250
COSM	94.4	174.3	264.4	103.0	186.8	306.7	-72.2	-136.3	-184.3	466	363	267
XTRP	89.9	182.4	271.7	110.8	220.4	315.5	-53.8	-114.8	-165.8	482	377	274
CY70	119.5	216.6	293.6	117.4	214.3	331.1	-100.1	-164.8	-169.6	242	182	122
CY85	125.6	224.1	315.2	133.3	226.2	322.1	-104.1	-173.8	-216.9	242	182	121
CY50	144.3	272.9	373.4	161.7	332.5	494.5	-109.9	-201.9	-229.3	242	182	122
CY30	216.8	407.8	546.1	260.3	494.0	703.8	-134.7	-276.1	-999.9	242	182	122

1978 TME STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CLIP	11.2	20.9	26.1	17.8	29.0	34.3	-.9	0.5	1.3	360	287	216
TOTL	12.5	22.6	26.5	20.6	32.1	36.0	1.9	5.7	2.6	492	374	273
OTCM	13.5	23.7	28.3	15.6	30.3	34.4	-7.8	-9.7	-10.9	158	109	40
JTWC	11.7	23.3	29.7	19.0	33.0	39.4	-1.0	-.3	-3.3	541	407	274
STRA	15.4	25.3	29.7	26.0	35.8	38.7	4.1	4.1	-.3	448	360	271
RECR	13.9	24.9	30.3	22.9	34.8	40.5	2.6	6.7	2.5	479	365	262
CY50	13.1	22.9	33.4	20.6	26.5	36.2	0.0	-9.4	-20.1	353	265	184
XTRP	12.5	24.0	34.1	19.5	31.2	40.6	-2.3	-6.5	-13.2	525	403	297
CY70	12.7	24.6	40.5	19.4	28.0	37.5	-1.7	-10.7	-29.7	414	306	222
CLIM	17.1	25.4	-999.9	26.2	34.5	-999.9	1.8	0.5	-999.9	498	366	0
HPAC	13.3	23.7	-999.9	21.0	32.6	-999.9	-.9	-1.7	-999.9	503	374	0
TPAC	13.3	23.7	-999.9	21.0	32.6	-999.9	-.9	-1.7	-999.9	503	374	0

1979 TME STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
JTWC	9.7	17.5	23.6	14.4	24.4	30.6	-.5	-.3	0.4	584	464	347
RECR	11.7	18.5	25.8	18.6	24.7	32.4	2.0	1.4	1.2	517	421	343
TOTL	11.8	20.2	27.3	18.3	27.1	35.4	1.6	3.0	2.8	541	443	357
TPAC	10.8	19.1	27.4	15.1	25.3	35.9	-1.8	-2.5	7.0	556	449	207
OTCM	10.3	19.7	28.6	12.0	23.4	34.7	-6.7	-8.7	-10.5	122	100	79
HPAC	10.8	19.1	29.0	15.1	25.3	37.1	-1.8	-2.5	0.9	556	449	208
CLIP	11.1	20.2	29.9	16.8	26.9	38.2	0.8	3.1	7.7	428	359	287
STRA	13.1	22.4	31.4	20.3	29.5	39.3	2.2	2.1	-.1	519	434	344
XTRP	11.4	21.0	31.6	16.4	26.0	37.1	-2.5	-6.8	-13.8	569	462	376
CLIM	13.3	23.2	31.8	18.9	31.2	40.8	0.1	2.0	12.1	561	456	210
CY50	11.4	22.0	35.2	17.5	30.1	40.3	-.1	-4.4	-14.9	425	341	243
CY70	11.5	21.9	36.9	17.8	26.2	37.0	-1.3	-9.9	-22.4	435	340	246

1980 TME STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	9.8	18.9	23.5	10.6	23.4	29.6	-6.4	-7.3	-7.9	154	126	80
HPAC	9.1	16.7	23.9	12.0	19.6	25.3	-3.7	-8.9	-14.7	469	370	281
STRA	10.4	17.6	24.4	17.1	21.1	25.8	-2.0	-9.5	-16.4	346	295	239
TPAC	9.1	16.7	25.7	12.0	19.6	28.4	-3.7	-8.9	-13.8	469	370	281
CLIP	8.8	17.5	26.1	12.0	23.4	31.6	-2.4	-7.0	-10.0	357	290	218
RECR	9.6	19.4	26.5	12.9	27.5	33.1	-3.6	-5.1	-7.0	410	330	246
TOTL	9.5	16.2	26.6	13.9	20.9	30.2	-1.6	-6.7	-12.6	411	335	256
CY50	9.6	17.8	26.8	13.4	21.1	28.6	-1.3	-9.5	-19.1	427	345	255
XTRP	9.5	18.1	27.9	12.3	20.3	31.1	-2.8	-9.8	-17.1	479	381	283
JTWC	9.2	20.1	28.0	13.2	30.2	38.2	-1.3	0.6	0.9	480	358	248
CY70	9.8	18.6	28.8	14.0	19.6	27.3	-1.6	-12.2	-22.2	423	332	244
CLIM	11.8	20.3	29.5	17.3	23.1	33.9	-3.9	-10.7	-13.1	480	371	287

1981 TME STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	10.3	17.7	18.1	14.1	27.0	28.4	-4.2	-2.8	-6.7	154	118	72
STRA	9.3	17.6	23.2	15.1	25.2	30.7	-3.2	-6.8	-8.9	364	301	220
JTWC	8.3	16.8	24.2	12.1	25.3	35.2	-1.7	0.4	-.4	453	338	230
BPAC	8.4	17.1	26.6	12.2	21.4	32.3	-2.0	-7.7	-11.6	430	344	260
HPAC	8.9	17.3	27.5	11.8	20.1	31.7	-4.2	-9.8	-14.6	441	344	262
TOTL	8.6	17.8	28.0	13.1	22.3	32.4	-2.1	-7.6	-13.8	405	327	252
CLIP	8.3	17.7	28.1	10.9	19.2	29.1	-3.8	-10.9	-19.1	363	288	222
TPAC	8.9	17.3	29.2	11.8	20.1	33.6	-4.2	-9.8	-14.0	441	344	265
XTRP	8.7	18.6	29.4	12.0	22.8	33.5	-2.9	-8.3	-14.3	445	341	258
RECR	8.8	18.6	29.4	11.7	21.6	33.9	-4.8	-10.3	-13.6	396	318	240
CLIM	11.2	21.2	31.5	14.0	23.6	36.3	-5.8	-11.7	-14.6	454	363	271
NTCM	13.1	23.9	36.3	17.4	28.9	40.7	-5.7	-9.6	-15.8	120	100	74
CY50	9.1	22.7	37.1	13.0	24.8	39.8	-3.0	-15.6	-24.3	403	315	232

1982 TME STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
JTWC	10.1	17.7	23.2	18.1	23.9	28.1	-.9	-5.2	-11.2	638	516	405
OTCM	12.6	19.3	25.1	22.9	28.0	33.7	-1.9	-1.8	-3.9	471	394	308
STRA	10.4	18.6	25.8	17.5	25.0	30.7	-2.1	-6.1	-11.2	575	496	411
TPAC	9.4	16.5	26.1	15.7	22.9	31.4	-1.7	-4.8	-11.0	615	522	429
TOTL	9.7	17.8	26.2	17.3	25.2	33.2	-.1	-2.1	-9.4	592	500	404
HPAC	9.4	16.5	26.4	15.7	22.9	33.0	-1.7	-4.8	-9.7	615	522	432
BPAC	10.2	17.0	26.5	16.9	24.1	35.2	1.2	0.0	-6.2	589	494	405
CLIM	12.2	19.9	28.2	18.9	25.0	32.4	-1.9	-5.5	-14.0	628	523	417
RECR	10.8	19.8	28.2	20.6	28.8	36.4	-1.0	-2.1	-6.9	573	486	402
CLIP	10.2	21.0	29.0	18.4	30.4	35.7	-1.3	-3.3	-10.6	538	467	383
NTCM	11.7	20.8	30.0	13.3	23.6	32.4	-6.8	-10.6	-16.2	179	150	120
XTRP	10.9	22.1	31.9	21.3	32.1	39.1	-.6	-3.2	-11.9	621	516	415
CY50	10.0	23.3	39.2	16.8	24.8	34.0	-3.5	-16.8	-32.0	567	491	406

1983 TME STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
HPAC	12.3	22.4	25.9	22.3	36.7	38.5	-1.0	-.1	-2.7	310	229	164
TPAC	12.3	22.4	26.1	22.3	36.7	38.6	-1.0	-.1	-4.9	310	229	165
BPAC	12.7	22.5	26.3	22.2	35.2	38.3	0.5	1.6	-.9	292	214	153
XTRP	11.1	21.4	26.4	21.5	31.8	34.4	-1.4	-2.2	-7.7	305	224	158
RECR	11.1	20.5	27.9	18.2	31.2	36.5	-3.7	-.8	1.6	284	212	156
CLIM	14.0	23.8	28.2	22.7	35.3	38.5	-1.8	-3.0	-8.5	307	234	166
CLIP	10.5	20.3	29.0	18.9	31.4	41.3	-2.5	-1.7	0.9	261	185	145
OTCM	9.0	18.8	29.0	13.6	29.3	42.0	-3.0	-2.5	1.8	262	185	131
NTCM	14.8	21.1	30.7	18.2	24.6	38.6	-8.0	-13.6	-12.9	263	191	148
JTWC	11.4	21.9	30.8	23.1	34.5	40.5	0.6	-.6	-7.6	335	247	173
TOTL	11.7	23.3	32.2	21.4	36.4	43.4	-1.8	-3.4	-7.8	298	222	161
STRA	13.6	26.6	33.6	22.8	42.4	45.2	-.7	-1.7	-9.4	287	212	157
CY50	10.0	26.0	42.3	12.4	16.7	21.5	-6.3	-25.7	-42.6	287	205	151

1984 TME STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	11.9	19.3	24.9	20.4	28.3	32.2	-2.2	-3.6	-11.5	471	354	224
JTWC	10.0	18.1	25.0	16.7	25.1	31.5	-2.9	-7.2	-11.8	486	366	276
TOTL	12.0	20.9	27.8	23.0	31.0	29.0	0.4	-5.9	-20.3	475	378	279
RECR	11.7	19.3	28.3	21.0	24.6	26.0	-1.9	-8.9	-22.4	463	362	279
CLIP	11.9	21.2	29.0	22.3	28.2	31.4	-1.7	-8.2	-19.9	415	332	258
XTRP	11.3	20.6	29.8	19.6	24.2	28.3	-2.9	-12.2	-24.2	494	379	288
COSM	12.0	20.6	30.0	19.3	23.8	30.7	-5.0	-12.3	-21.5	483	384	290
NTCM	11.3	22.2	33.3	18.1	27.1	31.7	-4.2	-11.7	-24.8	432	346	258
HPAC	13.1	23.7	33.8	23.0	31.5	36.2	-3.1	-10.0	-21.5	492	382	293
CLIM	17.6	26.3	34.6	29.1	33.4	35.3	-1.9	-11.2	-23.9	487	386	290
TPAC	13.1	23.7	34.7	23.0	31.5	38.0	-3.1	-10.0	-19.8	492	382	294

1985 TME STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
CSUM	9.5	18.0	22.8	16.1	22.9	24.5	-.2	-5.9	-13.6	76	58	42
OTCM	10.8	19.1	23.0	16.4	27.0	26.4	-3.1	-3.2	-15.3	463	340	181
JTWC	10.4	17.8	24.2	15.9	24.7	28.9	-2.4	-5.9	-15.2	462	346	224
NTCM	10.4	17.7	25.4	14.6	20.8	26.8	-3.2	-8.2	-16.9	373	290	198
TOTL	10.7	17.5	27.0	16.5	22.2	30.3	-1.1	-7.1	-15.8	447	341	243
HPAC	10.9	18.7	27.3	15.6	21.1	27.0	-4.2	-11.4	-21.9	477	363	259
CLIP	10.1	18.7	27.7	13.8	19.8	26.7	-4.5	-12.3	-22.4	342	267	188
RECR	11.4	19.0	28.4	15.7	23.0	32.7	-3.8	-8.8	-15.3	434	325	230
TPAC	10.9	18.7	28.6	15.6	21.1	29.5	-4.2	-11.4	-20.9	477	363	263
XTRP	10.8	20.1	29.3	15.9	23.3	31.9	-3.7	-11.1	-19.6	468	355	253
COSM	11.0	19.5	30.1	14.2	19.2	26.2	-6.2	-14.7	-27.4	457	352	250
CLIM	13.2	23.6	33.4	17.2	26.4	35.8	-5.0	-11.8	-20.0	468	365	256
CY70	15.0	26.4	34.1	16.1	21.1	26.6	-10.1	-22.5	-32.6	240	177	109
CY85	14.2	26.1	39.3	15.9	21.8	25.2	-9.9	-22.3	-39.1	238	179	109
CY50	16.8	32.4	47.4	16.0	28.1	38.7	-11.1	-23.1	-36.6	230	174	109
CY30	23.5	43.1	58.9	24.8	36.4	39.7	-11.6	-29.6	-49.5	225	163	103

1978 TKE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CLIP	66.8	117.1	151.7	82.9	153.4	196.0	-10.4	-7.4	0.7	368	294	227
TOTL	79.3	126.2	153.7	97.3	160.5	201.9	-15.9	-39.9	-46.3	503	391	305
RECR	82.8	133.4	160.4	103.4	172.3	216.9	0.9	-9.7	10.9	496	390	306
CY70	80.6	144.4	207.6	96.5	171.4	248.8	-30.6	-49.2	-55.3	428	328	242
JTWC	71.2	147.3	210.3	90.0	174.4	239.8	-18.8	-56.8	-103.4	556	420	295
STRA	89.5	161.8	225.0	107.2	190.1	248.8	-32.8	-88.5	-152.7	455	373	291
CY50	88.2	151.6	230.1	103.4	194.1	288.4	-35.1	-46.3	-62.0	363	280	206
OTCM	108.3	163.8	232.3	109.0	182.7	252.8	-70.4	-77.3	-97.4	160	113	40
XTRP	77.1	152.9	242.6	96.1	191.0	299.9	-28.2	-57.4	-112.9	542	418	327
CLIM	98.9	173.1	-999.9	126.7	220.0	-999.9	-20.9	-33.4	-999.9	516	386	0
HPAC	72.4	127.7	-999.9	91.6	156.0	-999.9	-20.6	-42.1	-999.9	515	385	0
TPAC	72.4	127.7	-999.9	91.6	156.0	-999.9	-20.6	-42.1	-999.9	515	385	0

1979 TKE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
TPAC	67.9	117.4	141.4	84.2	150.4	179.4	-11.9	-19.7	1.1	568	467	213
CLIP	65.3	110.3	155.6	82.0	140.0	193.2	-8.7	-.5	10.9	431	371	303
HPAC	67.9	117.4	158.9	84.2	150.4	205.1	-11.9	-19.7	-35.9	568	467	213
CLIM	81.6	132.3	161.9	104.8	171.2	188.9	6.6	23.4	43.9	576	472	217
TOTL	76.0	128.6	175.3	92.8	159.4	217.8	-21.0	-46.2	-71.6	550	464	383
RECR	75.2	130.8	176.2	95.9	175.9	241.2	-9.8	-15.9	-28.0	523	438	358
JTWC	71.1	130.3	183.2	87.5	167.1	239.7	-20.5	-40.4	-57.8	589	469	366
OTCM	53.7	116.8	187.8	65.5	144.6	227.0	-16.0	-32.7	-82.5	123	101	83
CY70	92.9	172.6	248.9	121.2	208.1	300.7	-38.9	-95.5	-109.1	444	357	264
XTRP	79.6	160.4	256.4	99.3	195.1	317.8	-27.5	-71.2	-124.7	581	482	398
STRA	90.0	176.8	266.6	103.7	193.9	281.5	-41.6	-118.3	-196.7	532	461	379
CY50	93.1	173.9	274.0	111.9	205.6	306.5	-40.7	-81.0	-136.3	432	356	259

1980 TKE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CY70	76.5	134.3	207.7	95.7	161.6	275.4	-29.2	-44.1	-44.6	430	348	262
HPAC	70.4	140.2	210.1	89.6	170.4	253.6	-19.9	-43.8	-61.7	475	380	294
JTWC	74.1	145.5	210.5	95.7	178.4	257.8	-8.9	-5.7	3.7	491	369	267
TOTL	72.5	141.3	214.0	89.5	161.7	234.9	-20.4	-71.5	-120.1	415	344	267
TPAC	70.4	140.2	220.9	89.6	170.4	264.9	-19.9	-43.8	-25.6	475	380	294
CLIP	71.3	149.2	225.5	92.7	194.9	283.2	-18.5	-43.9	-69.3	364	301	229
OTCM	67.6	148.7	229.5	82.3	180.6	259.7	-15.2	-59.3	-127.3	155	126	82
CY50	77.9	135.7	230.6	94.7	168.3	282.1	-35.5	-56.6	-111.3	435	355	269
RECR	76.1	159.9	238.3	93.3	189.1	284.6	12.9	16.6	-.3	415	344	267
CLIM	84.2	161.3	250.4	108.8	200.2	299.7	-9.1	-9.7	-3.8	486	389	301
STRA	79.9	177.3	283.7	90.2	172.4	252.6	-51.7	-153.6	-256.7	348	298	241
XTRP	83.4	179.7	294.2	101.3	212.9	318.1	-38.6	-103.2	-195.7	489	395	305

1981 TKE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
JTWC	75.6	119.3	168.2	101.8	162.0	239.9	2.0	-.3	8.7	466	348	246
OTCM	59.7	114.3	181.3	75.2	140.1	200.2	10.8	-19.1	-98.4	157	124	79
HPAC	67.4	127.7	189.1	85.9	162.9	239.9	-3.8	-6.2	2.1	444	348	271
NTCM	68.8	118.7	195.3	84.9	155.0	254.0	18.4	35.0	48.3	120	100	76
CLIP	63.8	132.4	214.0	85.1	172.3	265.6	1.4	6.2	41.1	369	292	222
TPAC	67.4	127.7	214.3	85.9	162.9	255.8	-3.8	-6.2	58.2	444	348	271
BPAC	76.1	151.0	232.6	100.1	184.9	272.1	5.9	27.0	74.2	439	352	270
STRA	85.0	174.1	235.5	106.7	198.4	282.7	-46.1	-124.6	-155.3	367	306	235
TOTL	77.7	149.0	238.5	98.5	187.0	294.5	-3.4	-26.7	-17.5	414	335	259
RECR	74.6	154.0	250.1	89.6	172.2	257.8	32.0	74.0	139.1	406	326	252
XTRP	76.9	166.0	254.5	98.9	200.7	312.4	-21.9	-71.1	-123.1	450	350	271
CLIM	87.3	175.3	262.3	107.1	204.3	292.0	13.1	48.4	106.5	464	371	287
CY50	79.1	159.7	294.9	106.7	243.0	481.7	-6.2	39.6	63.6	412	320	238

1982 TKE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
NTCM	63.1	102.0	164.1	69.5	128.1	207.7	36.2	36.1	29.3	180	152	122
HPAC	59.8	118.5	180.9	75.4	146.7	227.6	-15.3	-35.9	-57.8	628	537	450
TPAC	59.8	118.5	199.6	75.4	146.7	257.2	-15.3	-35.9	-38.0	628	537	450
JTWC	67.3	139.9	206.8	86.3	181.0	250.0	-10.1	-29.5	-81.4	660	532	425
OTCM	60.6	126.4	207.0	73.9	156.0	261.5	15.4	-10.4	-41.9	474	402	327
CLIP	60.5	132.6	208.1	76.6	164.4	251.1	-1.3	-9.1	-18.3	546	472	394
TOTL	70.3	137.9	225.4	88.6	164.5	259.2	-9.1	-54.1	-108.5	608	521	438
RECR	68.5	138.6	234.4	88.1	165.2	272.9	15.4	34.1	78.3	584	502	420
CY50	59.5	139.7	237.4	78.4	190.9	324.4	-11.6	-12.8	-24.7	575	494	406
STRA	70.1	152.7	239.7	87.8	177.5	277.4	-25.8	-81.5	-111.9	585	511	432
XTRP	64.7	147.6	240.7	83.1	184.2	295.9	-20.5	-60.3	-97.3	630	539	453
CLIM	85.1	156.4	241.4	107.4	202.0	313.2	-12.7	-11.9	36.4	643	551	464
BPAC	77.6	161.1	253.6	101.9	203.7	326.2	-6.9	-7.2	5.0	608	524	439

1983 TKE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
HPAC	60.9	122.6	187.7	74.6	143.9	203.4	-21.8	-41.6	-96.2	313	232	170
TPAC	60.9	122.6	200.3	74.6	143.9	224.6	-21.8	-41.6	-95.6	313	232	170
NTCM	65.4	122.8	204.5	84.0	152.0	244.3	-16.6	-29.9	-37.6	264	195	149
XTRP	63.0	138.6	226.7	81.7	176.6	266.4	-26.4	-69.0	-120.9	314	233	172
CLIM	84.9	157.6	232.3	107.7	195.0	268.3	-23.5	-51.8	-112.6	318	236	173
CLIP	62.9	140.8	233.4	82.4	173.6	291.4	-15.3	-28.8	-55.7	267	194	146
OTCM	56.6	131.1	248.6	70.4	156.9	277.4	-6.1	-39.2	-96.3	265	192	140
RECR	72.0	150.2	249.2	96.0	174.2	296.7	5.8	18.3	-5.0	287	215	160
JTWC	72.2	152.4	252.8	88.3	181.8	297.5	-15.0	-42.1	-80.0	342	253	184
BPAC	79.9	154.1	253.5	102.1	184.8	285.3	-22.8	-60.7	-128.0	299	222	160
CY50	59.1	165.3	269.8	78.8	237.1	400.1	-10.7	35.3	98.9	294	217	158
TOTL	73.6	163.1	280.7	88.6	186.3	314.2	-26.6	-76.1	-146.3	305	228	169
STRA	78.5	195.5	309.1	85.1	187.5	306.3	-45.5	-131.2	-191.9	294	220	160

1984 TKE STATISTICS

TECH	MEAN 24	MEAN 48	MEAN 72	STDEV 24	STDEV 48	STDEV 72	MEDIAN 24	MEDIAN 48	MEDIAN 72	COUNT 24	COUNT 48	COUNT 72
NTCM	53.2	110.3	198.2	69.3	136.1	245.2	-2.4	-21.3	-29.7	435	353	274
COSM	52.9	107.0	209.9	66.5	128.3	242.1	16.3	26.7	66.3	486	387	295
OTCM	72.7	144.2	226.8	88.2	170.6	261.8	1.5	-19.9	2.2	474	364	251
HPAC	70.0	147.1	228.6	85.1	176.0	260.6	-16.5	-45.0	-76.4	500	395	299
JTWC	66.2	137.9	231.8	87.8	167.6	288.8	-14.1	-44.1	-53.3	492	378	286
CLIP	66.3	148.0	241.6	84.3	176.0	281.8	-10.5	-29.1	-57.7	419	342	266
TPAC	70.0	147.1	248.1	85.1	176.0	295.5	-16.5	-45.0	-28.6	500	395	299
XTRP	67.7	155.5	269.9	86.6	184.4	305.5	-28.6	-92.5	-175.1	503	397	300
TOTL	83.7	177.3	288.0	105.2	212.3	326.4	-17.7	-62.4	-113.8	489	389	296
CLIM	101.5	206.2	291.8	126.6	259.4	356.5	-.8	-.2	-5.0	503	398	302
RECR	80.5	185.3	331.8	99.9	214.4	382.5	8.1	0.8	-3.8	472	376	289

1985 TKE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CSUM	56.5	85.1	92.8	65.2	99.1	117.1	-25.3	-30.5	-3.2	79	61	44
HPAC	63.6	124.9	191.6	78.7	153.6	233.5	-4.3	8.5	31.2	482	377	272
NTCM	64.3	124.9	193.4	80.8	151.3	230.0	-.1	5.4	7.1	383	304	223
COSM	53.7	109.5	198.2	69.0	139.2	249.3	12.0	40.5	60.3	465	362	266
CLIP	67.2	143.6	212.2	84.7	181.1	251.3	0.3	19.3	55.1	348	278	201
TOTL	71.3	145.3	214.7	88.9	179.5	268.2	-1.7	1.9	8.8	468	369	267
JTWC	66.5	135.1	219.4	84.3	176.9	300.2	-5.1	-.9	7.5	476	355	240
TPAC	63.6	124.9	224.4	78.7	153.6	268.3	-4.3	8.5	41.6	482	377	272
XTRP	70.7	150.8	225.4	88.0	192.4	290.3	-17.8	-27.7	-20.1	482	377	274
CY85	83.8	167.7	234.3	103.4	200.8	273.1	20.5	59.0	108.6	242	182	121
RECR	79.4	165.2	256.0	89.8	189.6	288.1	35.7	67.5	121.2	444	339	250
OTCM	62.8	138.3	263.3	77.4	168.9	316.5	-10.8	1.7	-20.1	474	365	224
CLIM	96.8	181.4	270.3	117.5	219.4	327.6	2.7	22.3	36.6	484	378	274
CY70	86.6	188.6	296.7	81.0	170.1	255.3	71.6	152.5	233.8	242	182	122
CY50	145.4	294.6	440.1	142.6	292.1	428.1	95.4	198.1	340.5	242	182	122
CY30	218.4	384.4	538.1	259.5	480.5	690.0	117.1	197.0	333.2	242	182	122

1978 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
TOTL	3.6	3.4	3.0	4.9	4.4	3.9	-.5	-.5	-.8	503	391	305
CLIP	3.2	3.2	3.1	4.1	4.0	3.8	-1.5	-1.4	-1.4	368	294	227
RECR	3.6	3.5	3.2	4.8	4.5	4.1	-.5	-.3	-.6	496	390	306
JTWC	3.9	4.0	3.3	5.8	5.4	4.0	-.9	-.7	-.9	556	420	295
STRA	3.8	3.7	3.4	5.1	4.9	4.0	0.2	0.4	0.5	455	373	291
OTCM	6.9	7.3	3.5	9.3	10.3	4.4	-.7	-1.7	-1.3	160	113	40
CY50	3.8	4.1	3.9	4.9	5.5	5.1	-.7	-.9	-1.0	363	280	206
CY70	3.8	4.2	4.0	5.0	5.7	5.1	-1.0	-1.0	-.7	428	328	242
XTRP	3.6	3.8	4.1	5.1	4.9	5.3	-1.5	-1.2	-.9	542	418	327
CLIM	8.3	10.3	-999.9	11.4	14.7	-999.9	-.3	0.3	-999.9	516	386	0
HPAC	6.3	8.7	-999.9	8.6	12.1	-999.9	-1.9	-2.3	-999.9	515	385	0
TPAC	6.3	8.7	-999.9	8.6	12.1	-999.9	-1.9	-2.3	-999.9	515	385	0

1979 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
JTWC	3.7	3.5	2.8	5.5	5.3	3.5	-.5	-.4	-.1	589	469	366
HPAC	4.8	5.3	3.1	6.3	7.5	4.1	-2.0	-1.8	-.8	568	467	213
TPAC	4.8	5.3	3.1	6.3	7.5	3.9	-2.0	-1.8	-.3	568	467	213
CLIP	3.4	3.4	3.1	4.4	4.3	3.9	-1.0	-.8	-.4	431	371	303
RECR	4.0	3.7	3.1	5.6	5.4	3.8	-.3	0.2	0.3	523	438	358
TOTL	3.8	3.6	3.2	4.9	4.6	4.0	-.4	-.1	0.0	550	464	383
OTCM	4.1	3.8	3.2	5.3	5.5	4.5	-3.1	-1.7	-.8	123	101	83
CLIM	5.7	5.6	3.5	7.8	8.4	4.2	-1.6	-1.1	0.1	576	472	217
XTRP	3.7	3.9	3.6	5.1	7.4	4.8	-1.3	-.8	-.9	581	482	398
STRA	4.1	4.3	3.9	5.3	5.3	4.4	0.2	0.9	1.1	532	461	379
CY50	4.1	4.2	4.1	5.8	5.5	5.2	0.0	0.4	0.2	432	356	259
CY70	4.4	4.7	4.3	6.6	7.4	5.9	-.4	0.1	-.4	444	357	264

1980 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
STRA	3.2	3.1	2.9	4.5	4.2	3.8	-1.4	-1.2	-.9	348	298	241
TOTL	3.4	3.1	3.0	4.6	3.9	3.6	-1.7	-1.7	-1.7	415	344	267
TPAC	3.7	3.3	3.0	4.7	4.1	3.6	-2.4	-2.2	-2.1	475	380	294
HPAC	3.7	3.3	3.0	4.7	4.1	3.5	-2.4	-2.2	-2.3	475	380	294
JTWC	4.3	3.4	3.0	6.3	4.6	3.7	-.3	-.5	-.9	491	369	267
CLIP	3.0	3.1	3.2	3.8	4.0	4.0	-1.7	-1.4	-1.6	364	301	229
RECR	3.7	3.2	3.2	4.7	4.0	4.0	-2.2	-1.8	-1.5	415	344	267
OTCM	4.8	4.3	3.3	6.3	6.1	4.1	-3.0	-.6	-.3	155	126	82
XTRP	3.5	3.6	3.4	4.8	6.1	4.3	-1.2	-.7	-.7	489	395	305
CY50	3.5	3.4	3.5	5.0	4.5	4.4	-.9	-1.4	-1.1	435	355	269
CLIM	4.7	4.0	3.6	5.9	4.7	4.4	-2.7	-2.6	-2.3	486	389	301
CY70	3.5	3.5	3.7	5.1	4.4	4.7	-1.4	-2.2	-2.2	430	348	262

1981 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
OTCM	4.2	4.3	2.7	4.9	6.8	3.9	-2.7	-.3	-.3	157	124	79
JTWC	4.0	3.5	2.9	5.7	4.9	3.9	-.4	-.7	-.3	466	348	246
STRA	3.4	3.2	3.0	5.4	5.6	4.2	-1.3	-.8	-.6	367	306	235
RECR	3.4	3.2	3.0	4.3	3.9	3.8	-2.4	-2.2	-1.8	406	326	252
TOTL	3.2	3.0	3.1	4.4	4.0	3.9	-1.5	-1.8	-1.7	414	335	259
HPAC	3.4	3.1	3.1	4.6	3.9	3.9	-2.5	-2.5	-2.5	444	348	271
TPAC	3.4	3.1	3.1	4.6	3.9	3.9	-2.5	-2.5	-2.0	444	348	271
BPAC	3.3	3.1	3.3	4.6	4.1	4.2	-1.4	-1.6	-1.5	439	352	270
XTRP	3.4	3.3	3.3	5.1	4.6	4.3	-1.3	-1.3	-1.3	450	350	271
CLIP	3.1	3.4	3.4	4.2	4.1	4.1	-2.3	-2.6	-2.6	369	292	222
CLIM	4.0	3.7	3.6	5.1	4.5	4.5	-2.6	-2.4	-2.0	464	371	287
NTCM	4.3	4.3	4.0	5.3	5.5	5.0	-3.1	-2.8	-2.4	120	100	76
CY50	3.5	4.0	4.7	5.0	5.5	6.5	-1.0	-.9	-.7	412	320	238

1983 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
HPAC	2.8	2.5	2.2	3.8	3.4	2.9	-1.9	-1.5	-1.0	313	232	170
TPAC	2.8	2.5	2.2	3.8	3.4	2.8	-1.9	-1.5	-.9	313	232	170
STRA	2.9	2.8	2.4	4.1	3.7	3.0	-1.2	-.4	0.0	294	220	160
CLIP	2.7	2.6	2.5	3.8	3.5	3.1	-1.6	-.9	-.3	267	194	146
RECR	2.9	2.5	2.7	3.8	3.2	3.2	-1.7	-1.2	-.5	287	215	160
BPAC	3.0	2.8	2.7	3.9	3.6	3.3	-.5	-.3	0.1	299	222	160
TOTL	2.7	2.7	2.7	3.7	3.4	3.2	-1.3	-.8	-.2	305	228	169
CLIM	3.4	3.1	2.7	4.4	3.9	3.4	-1.4	-1.1	-.9	318	236	173
NTCM	4.5	3.4	2.8	5.3	4.3	3.7	-3.6	-2.3	-1.8	264	195	149
OTCM	2.8	2.4	2.8	3.7	3.3	3.5	-2.2	-.9	-.3	265	192	140
XTRP	2.7	2.7	2.9	3.9	3.6	3.6	-1.1	-.6	-.2	314	233	172
JTWC	2.9	3.1	3.0	4.1	4.2	3.9	-1.0	-.7	-.5	342	253	184
CY50	2.9	4.0	4.4	3.9	5.2	5.7	-1.9	-1.2	-1.5	294	217	158

1982 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
STRA	3.2	2.9	2.6	4.2	3.8	3.2	-1.2	-.9	-.8	585	511	432
TPAC	3.2	2.9	2.7	4.2	3.7	3.3	-1.5	-1.5	-1.3	628	537	450
JTWC	3.6	3.9	2.7	5.2	6.4	3.4	-.4	0.1	-.7	660	532	425
TOTL	3.0	2.8	2.7	4.0	3.6	3.3	-.4	-.6	-.4	608	521	438
RECR	3.1	2.9	2.9	4.3	3.7	3.5	-1.2	-1.1	-.8	584	502	420
CLIP	2.9	3.1	2.9	3.7	4.0	3.6	-1.2	-1.2	-1.3	546	472	394
HPAC	3.2	2.9	2.9	4.2	3.7	3.5	-1.5	-1.5	-1.6	628	537	450
OTCM	3.6	3.4	2.9	4.6	5.1	3.5	-2.6	-1.0	-.2	474	402	327
NTCM	4.3	3.6	2.9	5.4	4.8	3.5	-3.4	-2.4	-1.7	180	152	122
CLIM	4.2	3.5	3.0	5.4	4.2	3.8	-1.2	-1.0	-1.1	643	551	464
BPAC	3.4	3.2	3.0	4.5	3.9	3.6	0.5	0.3	0.1	608	524	439
CY50	3.2	3.2	3.2	4.4	4.2	4.0	-1.6	-1.6	-1.7	575	494	406
XTRP	3.2	3.6	3.8	4.1	4.5	4.8	-.9	-.7	-.7	630	539	453

1984 SPE STATISTICS

TECH	MEAN 24	48	72	STDEV 24	48	72	MEDIAN 24	48	72	COUNT 24	48	72
JTWC	3.2	2.9	2.7	4.6	3.8	3.6	-1.3	-1.4	-1.3	492	378	286
OTCM	3.5	3.4	2.8	4.6	4.6	3.3	-2.2	-.9	-1.0	474	364	251
CLIP	3.1	3.2	2.9	3.9	3.8	3.6	-2.0	-2.4	-2.3	419	342	266
COSM	3.5	3.4	3.1	4.2	3.9	3.6	-3.4	-3.4	-2.7	486	387	295
TOTL	3.1	3.4	3.1	4.3	4.7	3.8	-.9	-1.2	-1.3	489	389	296
RECR	3.1	3.2	3.2	4.2	4.8	3.7	-1.3	-1.2	-1.2	472	376	289
HPAC	3.5	3.4	3.2	4.1	3.9	3.6	-2.6	-2.7	-2.8	500	395	299
TPAC	3.5	3.4	3.2	4.1	3.9	3.7	-2.6	-2.7	-2.5	500	395	299
XTRP	3.2	3.5	3.5	4.2	4.4	4.4	-1.7	-1.8	-1.7	503	397	300
NTCM	3.4	3.5	3.5	4.0	4.1	3.8	-3.0	-3.3	-3.2	435	353	274
CLIM	4.4	4.0	3.7	5.3	4.8	4.2	-2.2	-2.1	-2.3	503	398	302

1985 SPE STATISTICS

	MEAN			STDEV			MEDIAN			COUNT		
TECH	24	48	72	24	48	72	24	48	72	24	48	72
CSUM	2.3	2.5	2.5	2.6	2.9	2.9	0.3	-1.6	-1.9	79	61	44
OTCM	3.3	3.7	2.7	4.6	5.5	3.5	-1.5	0.0	-.4	474	365	225
COSM	3.5	3.3	2.8	4.4	3.8	3.3	-3.0	-3.1	-2.5	466	363	267
RECR	3.2	3.3	2.8	4.5	5.4	3.5	-1.1	-1.2	-1.4	444	339	250
JTWC	3.3	3.2	2.8	4.6	4.7	3.7	-1.0	-.9	-.7	477	356	241
TPAC	3.1	3.1	2.9	3.9	3.7	3.4	-2.1	-2.4	-2.1	482	377	272
TOTL	3.0	3.3	2.9	4.0	4.3	3.8	-.7	-1.1	-1.4	468	369	267
NTCM	3.1	2.9	3.0	4.1	3.7	3.7	-1.9	-1.7	-1.5	384	305	224
HPAC	3.1	3.1	3.0	3.9	3.7	3.4	-2.1	-2.4	-2.6	482	377	272
CLIP	3.1	3.1	3.0	4.0	3.9	3.6	-1.8	-2.0	-2.4	348	278	201
CLIM	3.8	3.5	3.1	4.7	4.3	3.7	-1.5	-1.7	-2.0	485	379	274
XTRP	3.1	3.3	3.4	4.2	4.1	4.2	-1.2	-1.5	-1.6	482	377	274
CY85	3.9	3.4	3.4	5.2	4.0	3.7	-3.2	-2.9	-3.0	242	182	121
CY70	4.1	3.7	3.6	4.8	4.2	4.0	-3.8	-3.3	-2.7	242	182	122
CY50	4.9	4.9	5.2	6.4	5.8	5.9	-1.3	-1.1	-.6	242	182	122
CY30	8.5	8.4	8.3	11.4	10.4	9.8	1.7	0.6	1.0	242	182	122

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